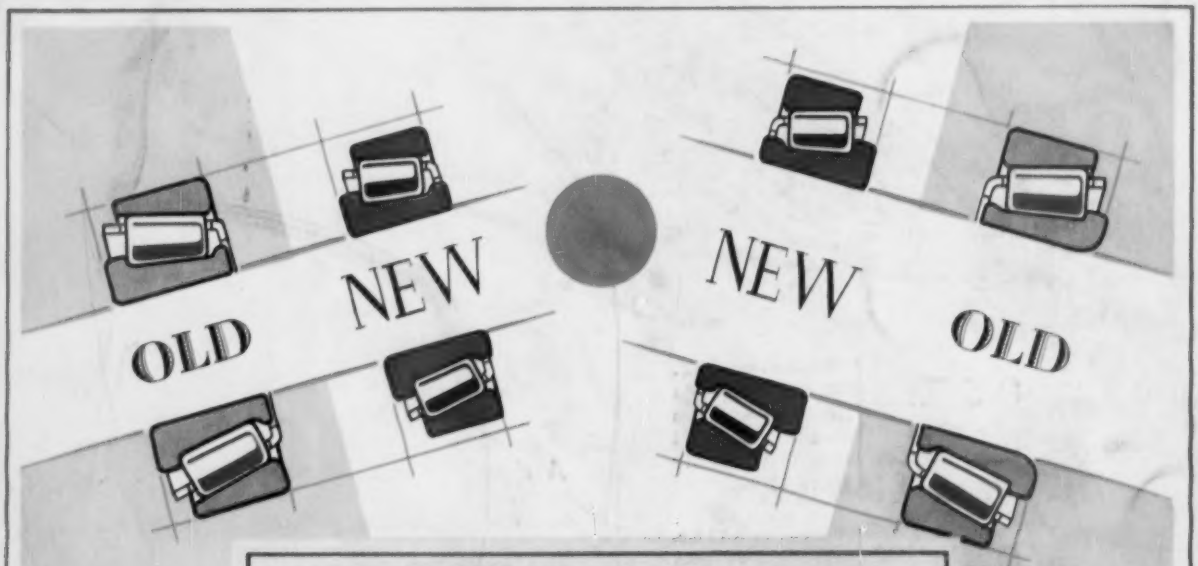
AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 46 No. 13 DECEMBER 1956 PRICE: 3s. 6d.



Saving in weight and money

Two very compact bearings which we introduced last year are now being extensively used on stub axles and elsewhere. The illustrations show the comparison with bearings previously popular for these applications. While the new bearings are of the same bores as before, to suit typical stub axles, they are smaller in the O.D. and in width, and are 25% lighter.

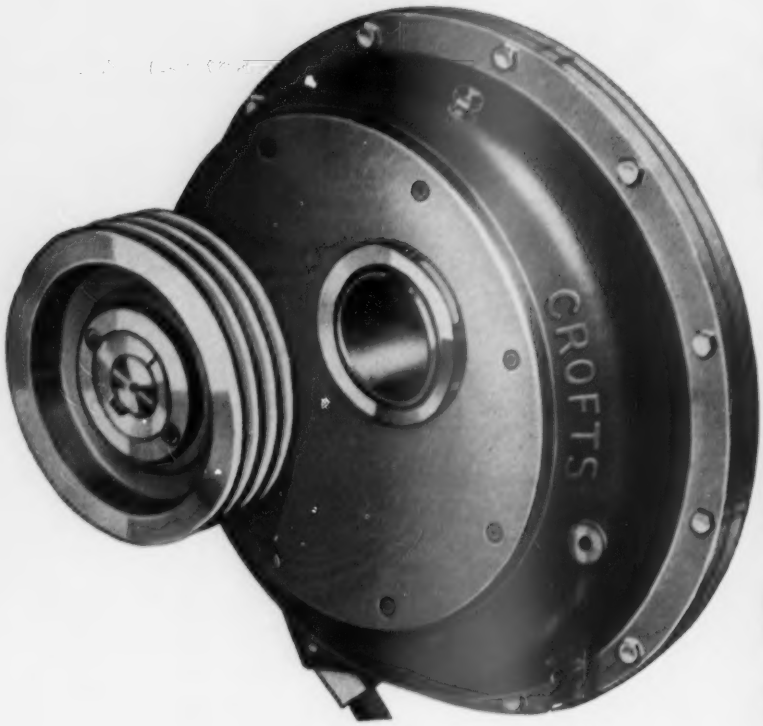
They may be put a little closer together and still give the same effective spread, so that the savings in size are three-dimensional, and the hub, the seal, the hub-cap—even the amount of grease—are reduced, saving in cost and weight —and unsprung weight at that.

MADE IN ENGLAND BY BRITISH TIMKEN LTD

DUSTON, NORTHAMPTON (HEAD OFFICE): DAVENTRY & BIRMINGHAM

TIMKEN Regd. Trade Mark: TIMKEN

tapered-roller bearings



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SHAFT MOUNTED GEAR UNITS

8 SIZES of SINGLE REDUCTION GEARS — POWERS up to 110 h.p. OUTPUT SPEEDS from 100 to 425 r.p.m. when used with CROFTS SUPROR SURE-GRIP V-ROPE DRIVES.

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Used in combination with other standard Crofts products, a much wider range of torques and speeds (including infinite variation) is possible.

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SIMPLE MOUNTING direct on to the machine shaft, whatever the angle, eliminates couplings, baseplates and foundations. This makes an ideal drive for vertical or inclined agitator shafts in chemical and food processing machinery, as well as for any horizontal application.

INTERCHANGEABLE BUSHES facilitate fitting on a wide range of shaft diameters.

DIFFERENT SPEEDS easily obtained using quick-change Crofts Taper-Flushbush pulleys.

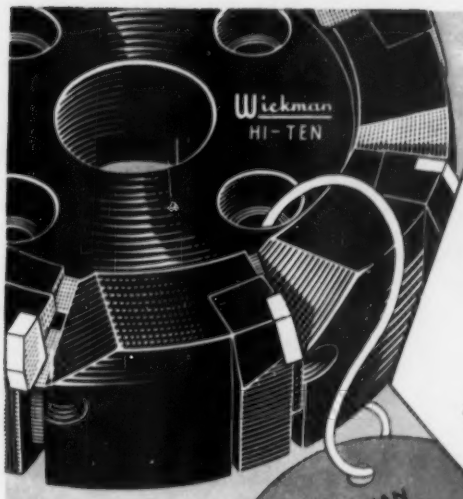
BELT TENSION simply adjusted by the torque reaction bar.

WRITE FOR PUBLICATION No. 655/1.

Units can carry driving motor as shown, or be supplied fitted with flange mounting motor.

Crofts (ENGINEERS) LIMITED. BRADFORD 3. ENGLAND

PHONE - 65251 (15 LINES) GRAMS - "CROFTERS BRADFORD"



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2 new
CARBIDE MILLING CUTTERS

✓ *Right for performance*
✓ *Right for price*

WICKMAN
HI-TEN
FOR STEELS
£25-10-0
8 in. DIA. 8 BLADES

WICKMAN
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FOR CAST IRONS
AND NON-FERROUS METALS
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Dia.	Number of Blades	Price Cutter Complete	Price Blades Each
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6"	6	18 5 0	1 8 6
8"	8	25 10 0	1 8 6
10"	10	34 0 0	1 8 6

Standard Spindle Nose Fitting

Prices ex Coventry Works

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PRICES FOR NON-STANDARD SIZES QUOTED ON REQUEST.

Many Standard Cutters Available from Stock

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MAGNETIC AND NON-MAGNETIC PARTICLES FROM METAL CUTTING FLUIDS

WITH

New BARNESDRIL

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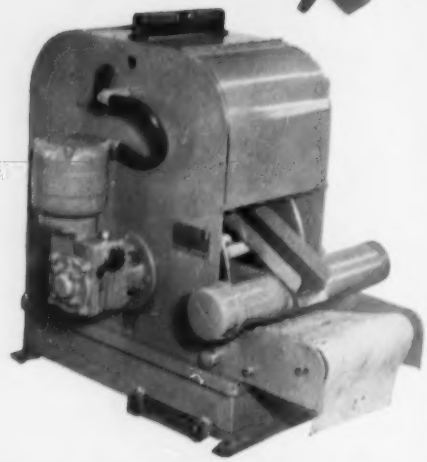

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Efficient BARNESDRIL Automatic Magnetic Coolant Separators sharply reduce machine maintenance and downtime, increase finish quality, and prolong coolant life. New BARNESDRIL developments offer even greater improvements in coolant supply and chip disposal.

Kleenall Filters Are Plant Proven On Our Own Production Equipment

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FOR UNUSUAL MACHINES

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FULL UNIVERSAL
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Electrically Operated—Air Controlled

...Drilling —TYPE DR

Capacities from No. 60 through ⅜ in. in two sizes

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Capacities from No. 0 through 1¼ in. in five sizes

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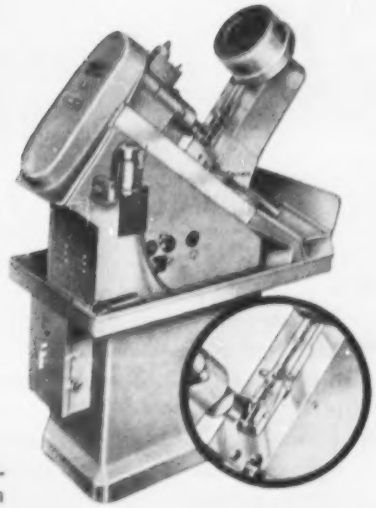
Capacities up to 1 in. in two sizes

AUTOMATIC and SEMI-AUTOMATIC
JIGS and FIXTURES
for Indexing and Clamping

A complete line of basic Master Fixtures to permit adaptation of a wide range of parts at high production rate with low tooling cost. Built-in controls permit synchronisation of fixtures with machine cycle.



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Nut Tapping Machines

Completely automatic, hopper feed, nut tapping machines up to 1 in.—incorporating simplicity and low tooling cost. Standard taps are used. Precision class 3 and 4 fits and parallelism maintained at high speed and high production.

GASTON E. MARBAIX LTD

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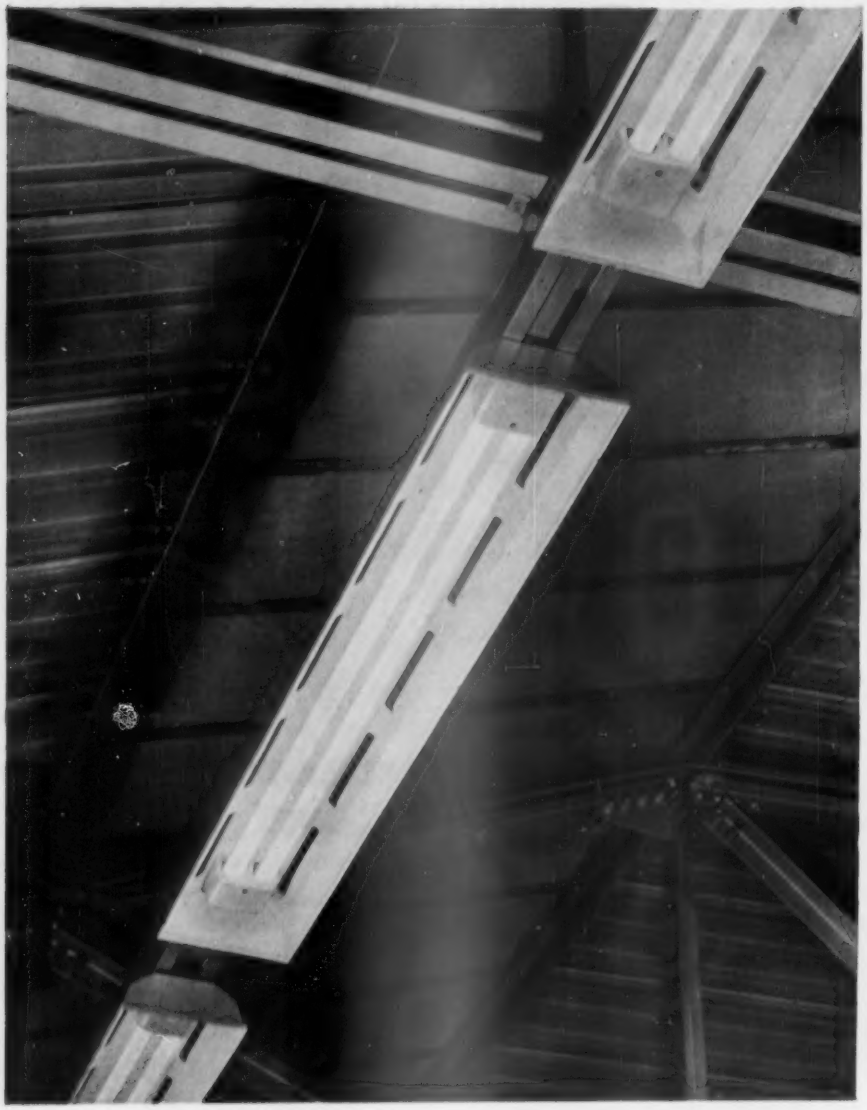

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- *Installation costs are considerably lower than equivalent schemes using individually suspended units with conduit tubing.*
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G.E.C.

The General Electric Co. Ltd,
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One of the neatest design details in the modern automobile is the pressed-steel housing of the Borg & Beck clutch.

In a simple manner, it provides the drive to the pressure plate, pockets for the pressure springs, and of course a housing which permits the use of a simple flat-faced flywheel, with its many production advantages.

And, into the bargain, the housing functions to a useful extent as a centrifugal fan, efficiently cooling the clutch.

BORG & BECK

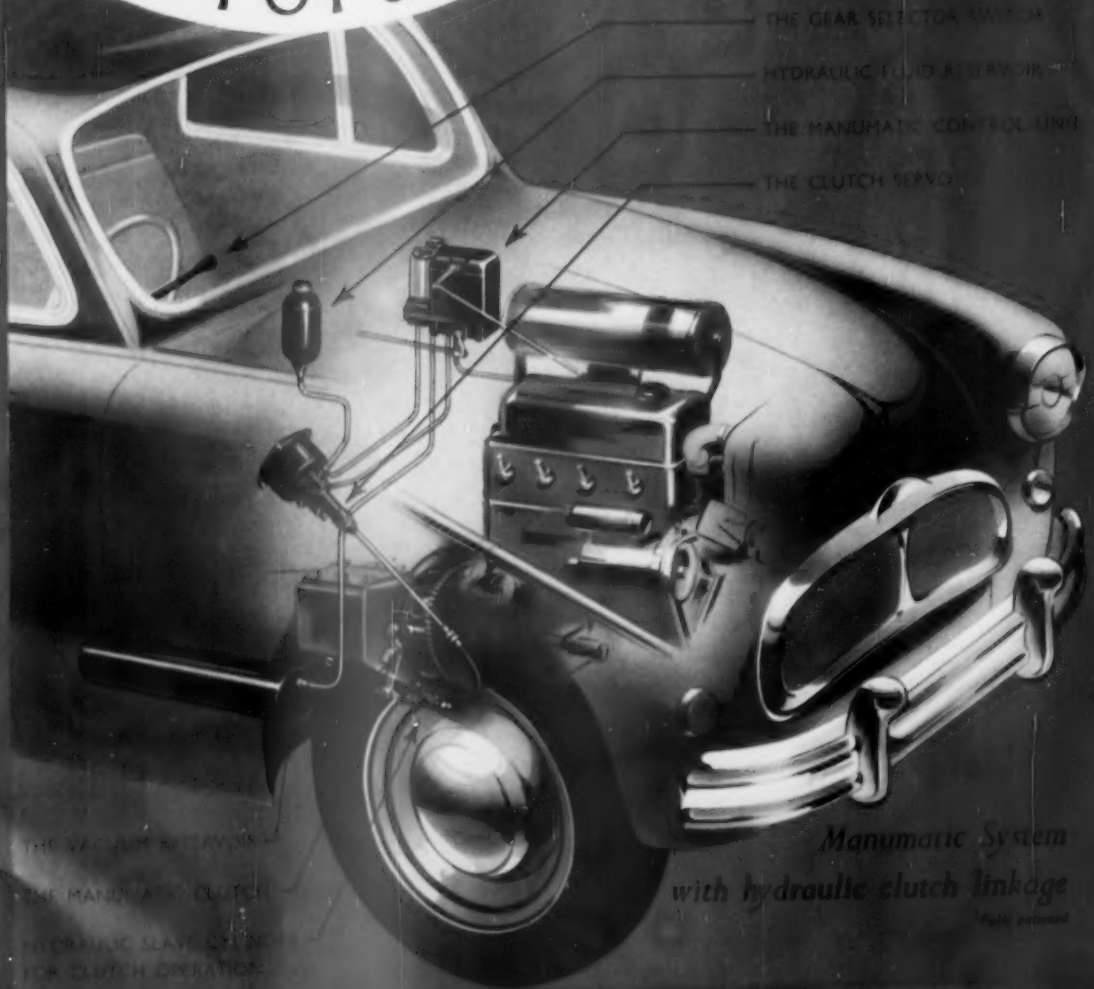
BORG & BECK COMPANY LIMITED, LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

Regd. Trade Mark: Borg & Beck

THE PERFECT SYSTEM

Manual selection automatic change

FOR THE POPULAR CAR



Manumatic System
with hydraulic clutch linkage

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THE DRIVER HAS ONLY TO

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and a perfectly synchronized
change is made automatically

USES NORMAL GEARBOX

Low in cost

EMBODIES WELL-PROVED
BORG & BECK CLUTCH PRACTICE
BUT WITHOUT PEDAL

EASILY INCORPORATED
IN EXISTING
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Protected from harmful abrasives

On the Austin diesel 3-tonner

The Purolator owes its success to its plastic-impregnated paper filtration element of specially controlled texture, the result of pioneer work carried to a high degree of perfection.

The pleated paper construction of the element provides an exceptionally large filtering surface. It can prevent the passage of particles of dust, down to microscopic sizes, which can cause excessive wear or damage to the engine.

Tests have proved that with this type of filter high flow rates are maintained over very long periods.

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Micronic OIL & FUEL FILTERS

AUTOMOTIVE PRODUCTS COMPANY LTD., LEAMINGTON SPA, WARWICKSHIRE

Registered trade marks: Purolator and Micronic

It's Lighter!

Real progress in human history seems to come in sudden spurts.
Thus our ancestors took a clear step forward into the bright light of civilization
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ten or twelve pounds of solid stone club when popping the
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into power tools of a lightness and handiness previously unheard of.

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DURALUMIN

REGD. TRADE MARK

takes a load off overheads

In this drop-sided truck, 'Duralumin' saves wear, tare, tyres, fuel and tax. Mounted on a standard B.M.C. chassis, its capacity has been increased by a third, and yet the weight has been kept down sufficiently to qualify for the same rate of tax. After extending the chassis by 3 ft. 9 in. with a Baico extension, the truck was fitted with a 21-ft. 'Duralumin' body instead of the 16-ft. standard body normally supplied by the manufacturers.

This use of 'Duralumin' may suggest applications in your own vehicle construction. Strong as steel yet only a third its weight, corrosion-resistant, hardwearing and easy to clean, this rustless light alloy offers important advantages to all vehicle operators.

(Above) The 7-ton B.M.C. forward control Diesel chassis fitted with a 21-ft. body. Premier Motor Company (Birmingham) supplied the chassis. Bodywork was built by the Duramin Engineering Company—an entirely independent organisation.

(Right) Mechanic's eye-view of the chassis showing the Duramin Engineering Company's tongued and grooved 'Duraplank' flooring made from 'Duralumin'.

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Extrusions, large forgings, plate, sheet, strip, tubes and wire in brass and copper, as well as light alloys

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DE NORMANVILLE
Overdrive

ON THE NEW ROVER MODELS

Already available as optional equipment on the three fine Rover models—the 2-litre '60', the '75' and the '90', the Laycock de Normanville Overdrive is now adopted as standard equipment on the distinguished newcomer, the Rover '105s', a car designed for high and untiring performance. Additionally, the fully automatic transmission of the 2-pedal '105R' designed by the Rover Company after extensive development work, consists of a Rover built torque convertor and 2-speed gearbox incorporating the Laycock de Normanville overdrive. Thus it is a tribute to the quality and efficiency of the Laycock unit that it has been chosen for the whole Rover range of five cars to provide an extra high ratio for smooth fast cruising with maximum fuel economy.

Laycock
DE NORMANVILLE
Overdrive

. . . overdrive with fully automatic operation for all ROVER models

LAYCOCK ENGINEERING LIMITED · SHEFFIELD

Enquiries to: Laycock Engineering Ltd., Overdrive and Transmission Sales Division, 16/17 Hertford Street, Coventry.

Under exclusive licence from Auto Transmissions Ltd., Coventry. Electrical controls by Joseph Lucas (Electrical) Ltd.

The general purpose press of the British Motor Industry

Hundreds of Hi-Ton Presses are employed for forming, drawing, assembling, riveting and punching operations on automobile parts. They are made in a range with pressures up to 300 tons.

The illustration shows one of a group of machines studding hubs at the Tractor and Transmissions Branch of Morris Motors Ltd.

Write to-day for further details.

Sales & Service for . . . **DRUMMOND-ASQUITH** *. . . the British Isles.*

DRUMMOND-ASQUITH (SALES) LTD., KING EDWARD HOUSE, NEW ST., BIRMINGHAM

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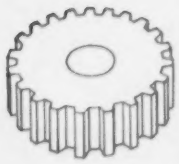
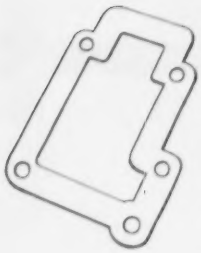
HF 178

Dressing for the part





Are you taking advantage of the latest developments in the packaging of machine parts, accessories and spares? Amongst the designs now produced by Robinsons of Bristol are flexible packages to cover the handling, storage and display requirements of almost every type of mechanical product. They include printed paper bags of every size, with double walls or oil-and-grease-resistant linings and strongly-welded flexible containers of coloured polyethylene film and P.V.C. Attractive designs, incorporating manufacturers' brand names, give clear identification at every stage of distribution.

This new approach to the handling of spares is typical of Robinsons' application of better packaging and printing techniques in almost every Industry. If you feel that your product is handicapped by outmoded dress, we invite you to take advantage of Robinsons' skill, ideas and resources.

R

Pouches and wrappers
Bags and envelopes
Self-erecting cartons
Rigid boxes
Acetate boxes
Printed corrugated paper
Posters
Display material
Fine colour printing

BAG DIVISION

Robinsons *of Bristol*

E. S. & A. ROBINSON LIMITED, BRISTOL AND ASSOCIATED COMPANIES

The NEW SAFFIRE
COMBINED OUTFIT

FOR
WELDING
CUTTING
HEATING
FLAME CLEANING

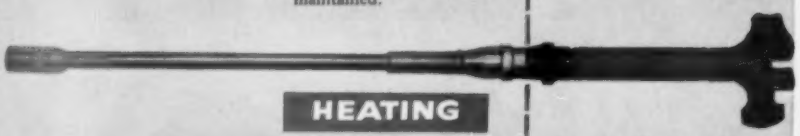
Here for the first time is an outfit that can be used for all these operations. The basis is a common shank to which the various heads for welding, cutting, heating and flame cleaning can be fitted, easily and quickly. With one shank you can build up the set with some or all the heads to meet your needs as they occur. Alternatively you can buy the complete outfit with the entire range of heads in a portable case.

WELDING

A complete range of swaged or detachable tips is available covering all welding requirements up to 1".

CUTTING

The cutting attachment will cut steel up to 2' thick. The highest degree of safety is ensured by the use of *nozzle-mixing*, limiting any possibility of backfire to the nozzle itself and allowing maximum cutting speeds to be maintained.



HEATING

The nozzles screw on to the straight welding neck or on to flexible necks which can be bent to any angle.

FLAME CLEANING

Flame cleaning attachments screw directly into the mixer and consist of a bent neck or a straight neck with a range of detachable flat or round nozzles.

BOC **BRITISH OXYGEN**

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When Rolls-Royce needed a "cradle" to protect their compresser blades during the stages of manufacture, the answer was a strong, double-walled cardboard box designed by Robinsons. These economical boxes have special individual compartments which keep the blades secure from abrasion during handling.

Slots were carefully designed to support the bosses of the blades at all stages, despite constant changes in sizes due to machining. Replaceable tops were also provided for easy renewal, since the heaviest wear occurs at the point of insertion. All these requirements were met in compact designs which fit existing bins and permit convenient handling by operators.

This co-operation with Rolls-Royce is typical of the way in which Robinsons tackle packaging problems. Consultation with Robinsons can almost certainly save you time, trouble and labour in *your* production process. We invite your enquiries.

Pouches and wrappers
Bags and envelopes
Self-erecting cartons
Rigid boxes
Acetate boxes
Printed corrugated paper
Posters
Display material
Fine colour printing

RIGID BOX DIVISION

Robinsons *of Bristol*

E. S. & A. ROBINSON LIMITED, BRISTOL, AND ASSOCIATED COMPANIES

STAY OUT OF THE STOCKS

If you really want to upset a native of the charming old-world village of Nether Ditchling, say to him "Something must have happened to my brakes". Instinctively he will glance over his shoulder for the erstwhile lorry or coach. Lying as it does at the bottom of a steep hill, Nether Ditchling is sick of both the saying and the sight. So much so that it has instituted its own corrective. Though the method is ancient, the reasoning is modern. Nether Ditchling believes that there are three solutions to the problem of their hill and the crashes on it: remove the hill, which is almost impossible; build a by-pass, which is highly improbable; equip vehicles with the Clayton-Oetiker Exhaust Brake, which is extremely practical. Nether Ditchlinians are so convinced of the virtues of this method of retardation, that they make an example of non-believers. If you're going their way, don't get stuck in the stocks!

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THE BRAKE THAT NEVER FADES

CLAYTON DEWANDRE CO. LTD.

TITANIC WORKS · LINCOLN · ENGLAND

EB4

INDUCTION FACTOTUM

Versatile

Medium Frequency

Power Unit

BIRLEC

A widespread need for a simple, compact and versatile induction heating power unit is met by the new Birlec medium frequency power package. The robust and reliable motor alternator is housed in a self-contained cubicle with built-in controls and meters, that can be placed anywhere in the factory. Ideal for hardening, annealing, brazing, sintering and melting applications, the unit may incorporate a heating head or may serve several alternative heating stations. Birlec publication number 141 gives further details.

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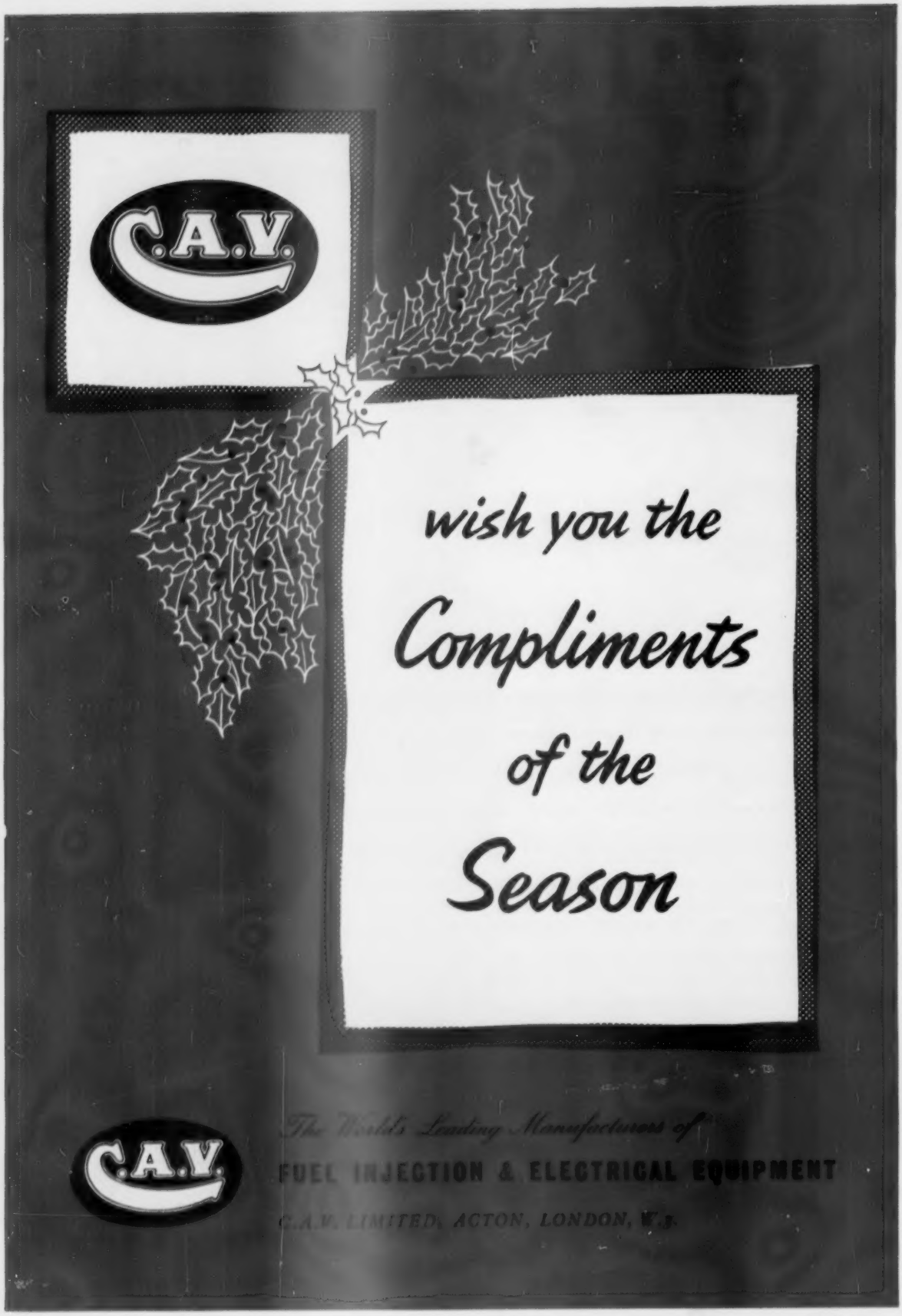
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Compliments
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The World's Leading Manufacturers of
FUEL INJECTION & ELECTRICAL EQUIPMENT
C.A.V. LIMITED, ACTON, LONDON, W.3.

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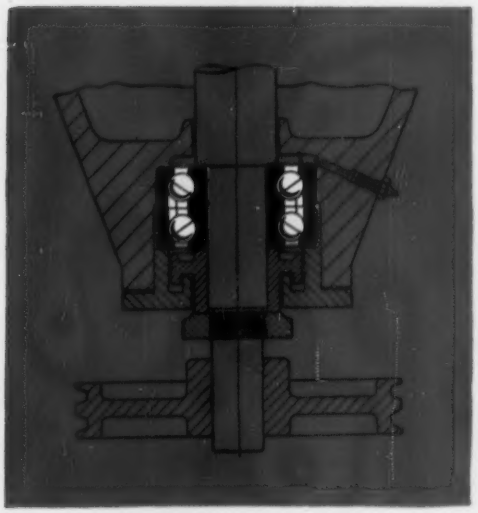
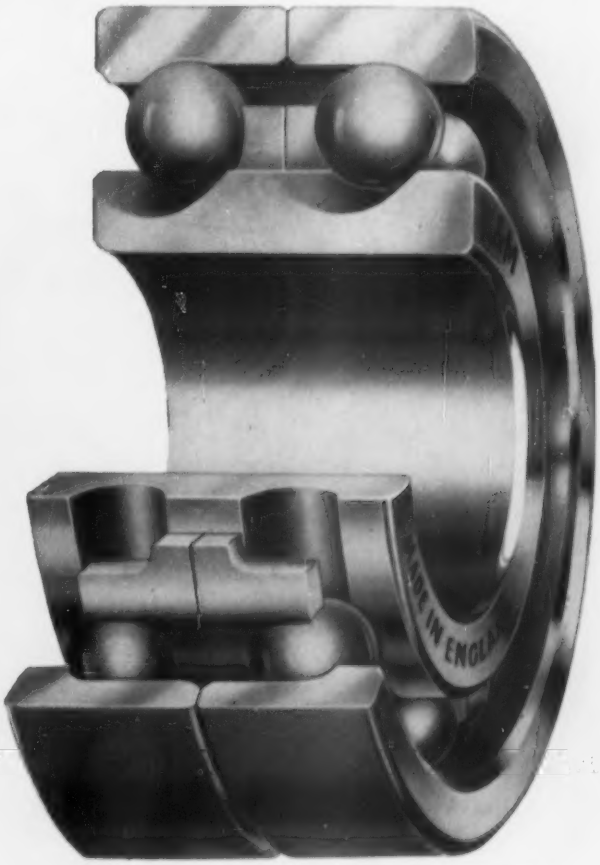
Apart from ordering . . .

. . . Ransome and Marles ball and roller bearings I never think about them. They are specified and fitted in so much machinery that I take their reliability for granted.





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Marles Bearing Co., Ltd.

Newark-on-Trent, England

Telephone: Newark 456 and Telex 37-506

BALL & ROLLER R&M BEARINGS

Presenting

A NEW

8 Speed Gear Box

Inclusive of Overdrive

MOSS GEARS

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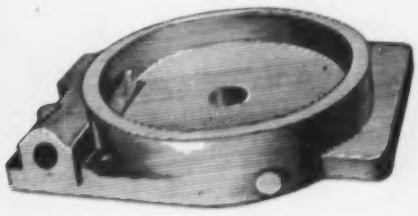
Telephone: ERDington 1661/6. Telegrams: "MOSGEAR, BIRMINGHAM."

He's just going to use another of those

HARPER CASTINGS



120 lb. casting for machine tool component.

The machine tool industry like many others has learned through experience to put trust in Harper Castings, both for its own tools and for machine work generally.

Harper quality covers grey iron and Meehanite castings, also metal pressings, machining, enamelling and other finishes and sub-assembly work.

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JOHN HARPER & CO. LTD.
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ALBION WORKS · WILLENHALL · STAFFS

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Versatile stuff – **BURY FELT**

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VAUXHALL . . . an internationally illustrious name in the motor industry—and for accurate, economic production of many components, Vauxhall Motors Ltd. have installed Newall Grinding Machines.

Finish grind of the bearing diameters on this main driving pinion was a single operation with twin wheels—an example of the many applications for increased productivity obtainable with the

NEWALL

MODEL LA

CYLINDRICAL GRINDER

ILLUSTRATED BROCHURE AND FULL DETAILS SUPPLIED ON REQUEST TO—

NEWALL GROUP SALES LIMITED

PETERBOROUGH — TELEPHONE 3227-8-9

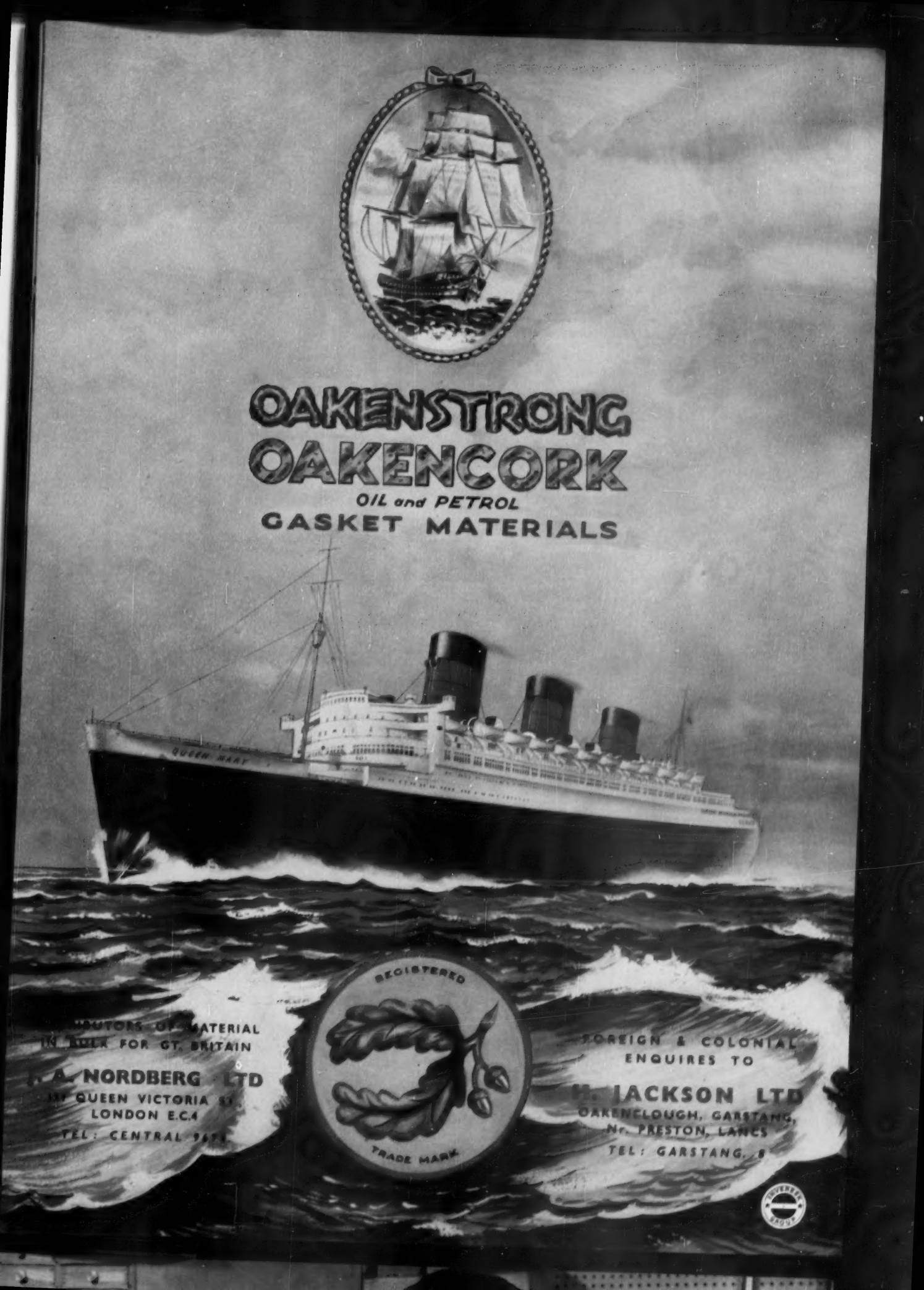
cut out that operation!

The production engineer is allergic to operations ; he says they cost too much. So more and more production men are changing over from the older machine screw to the self-tapping type.
For the self-tapping screw, by forming its own thread, cuts out completely all screw-cutting operations ; and, because of its self-locating point, greatly simplifies assembly. It never needs a nut, however thin the parts to be joined.
Moreover, the recessed-head type of self-tapping screw permits the use of power-drivers, without risk of harm to worker or work. The production men *have* something there, haven't they?

Linread

LINREAD LTD · COX ST · BIRMINGHAM 3

SLOTTED AND PHILLIPS RECESSED HEAD MACHINE SCREWS AND TAPPING SCREWS · HIGH TENSILE HEXAGON HEAD BOLTS AND SETSCREWS AIRCRAFT BOLTS, SCREWS AND RIVETS · SEMS · RIVNUTS · CUSTOM DESIGNED COLD FORGED FASTENERS · ALEX SCREWPLUGS.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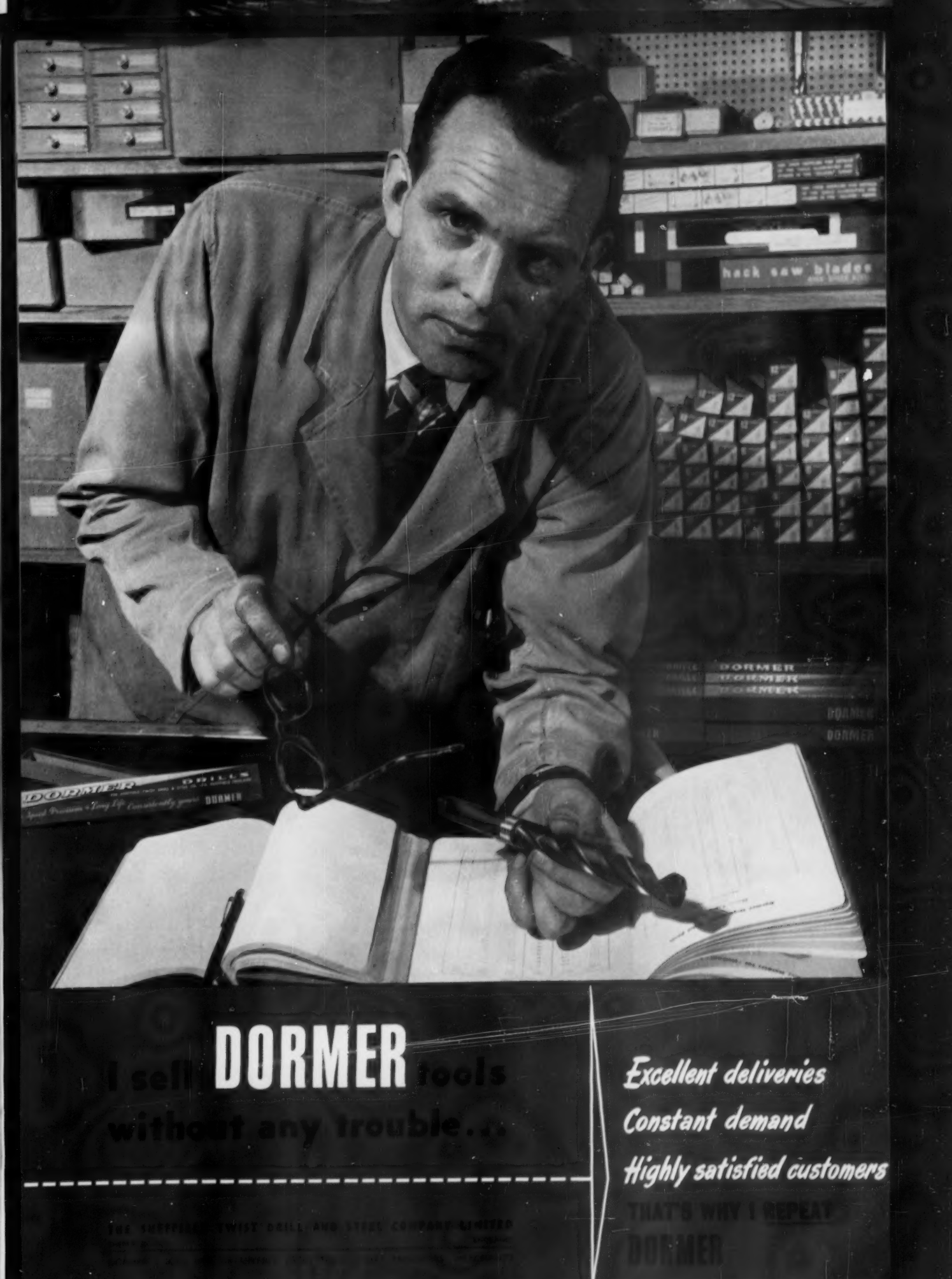

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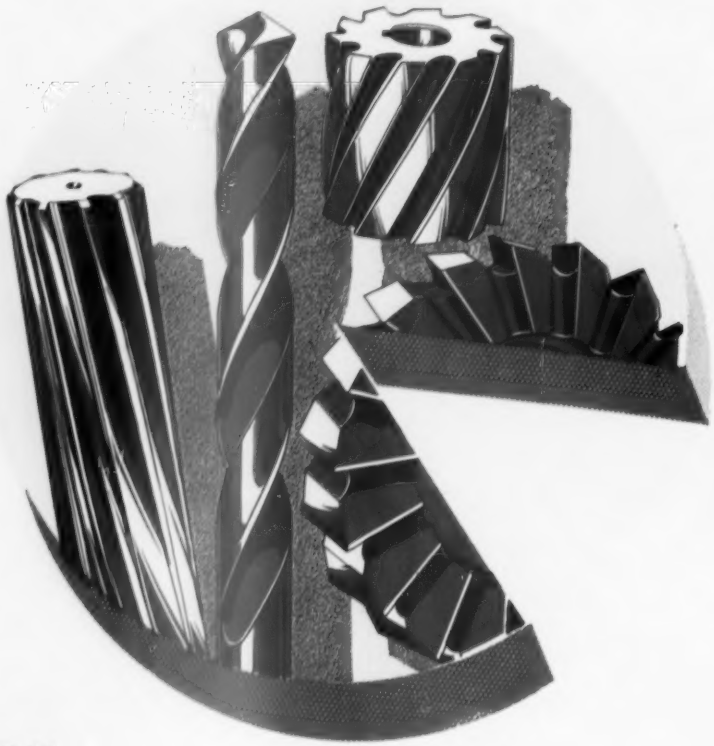

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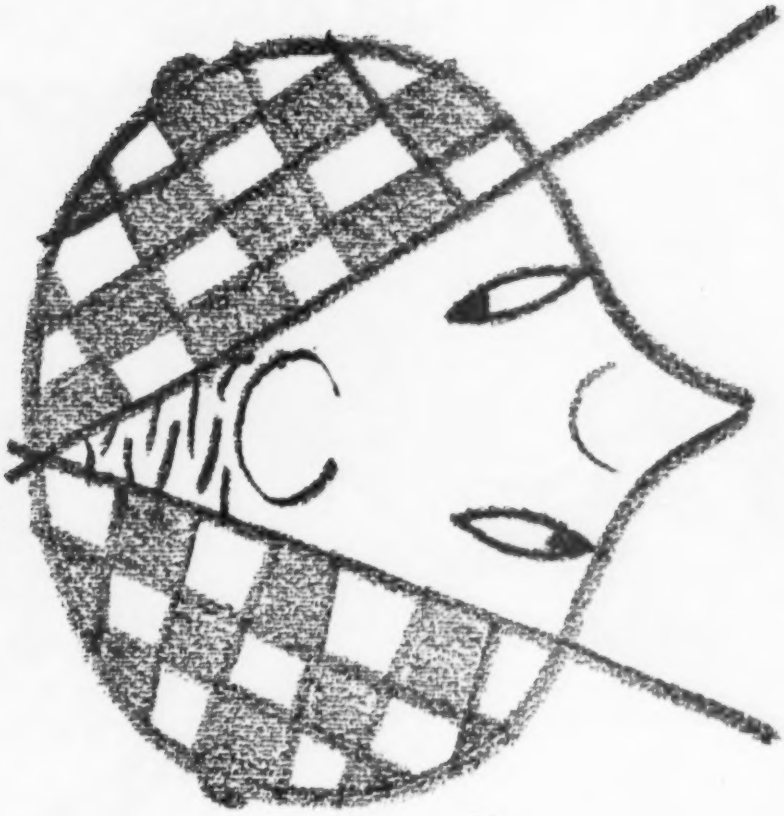

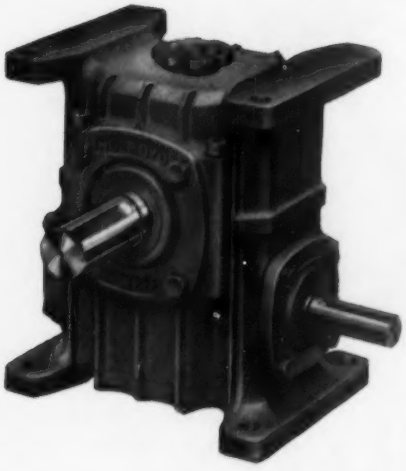

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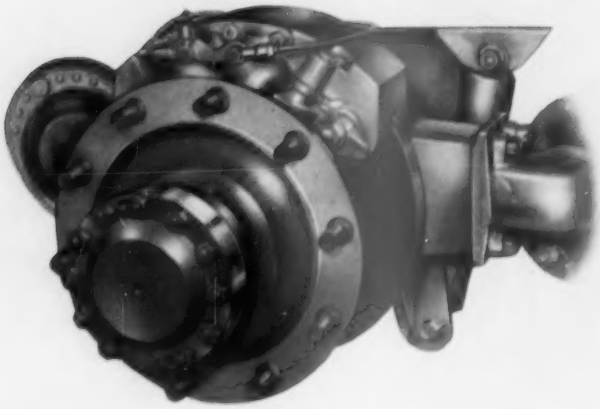

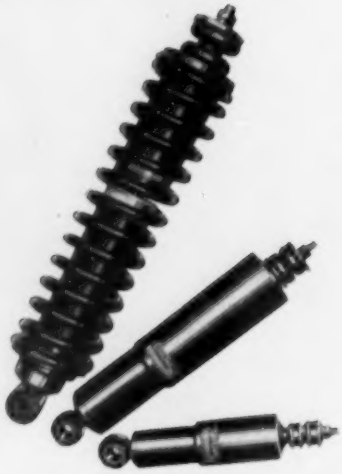

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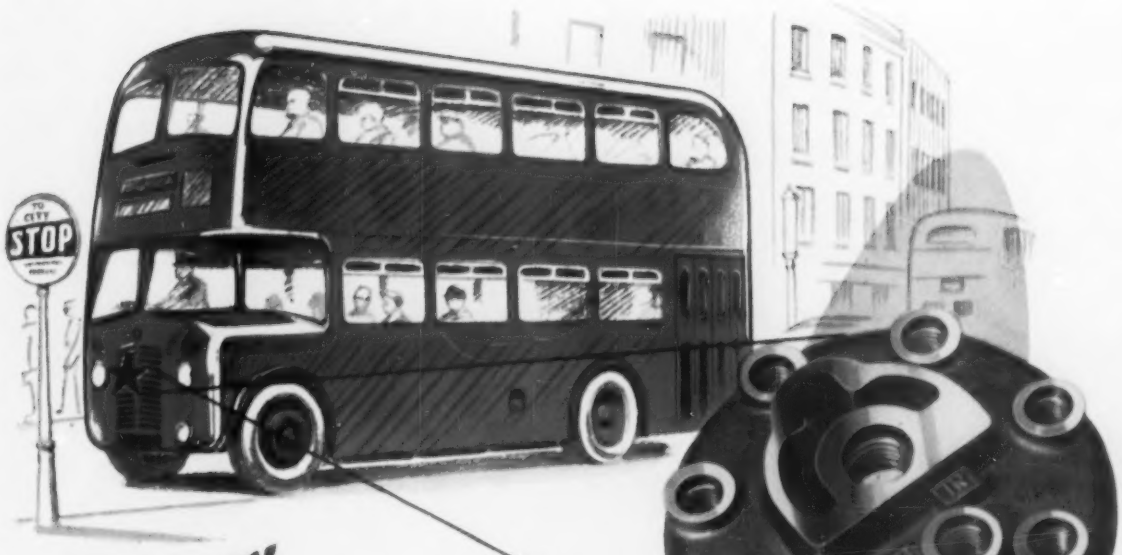

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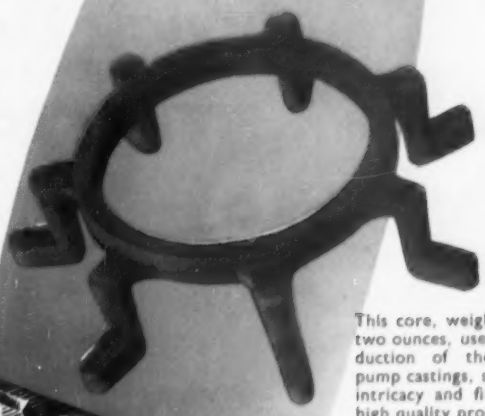
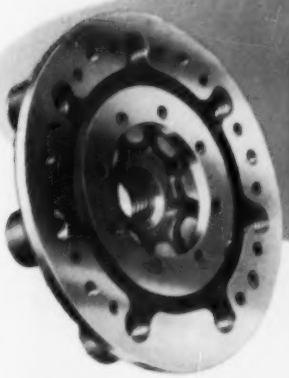


This core, weighing less than two ounces, used in the production of these hydraulic pump castings, symbolises the intricacy and fineness of this high quality production.



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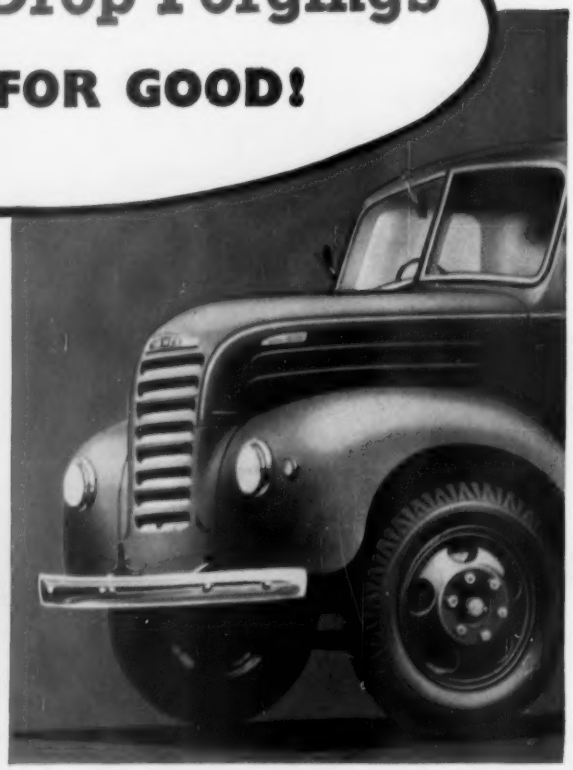

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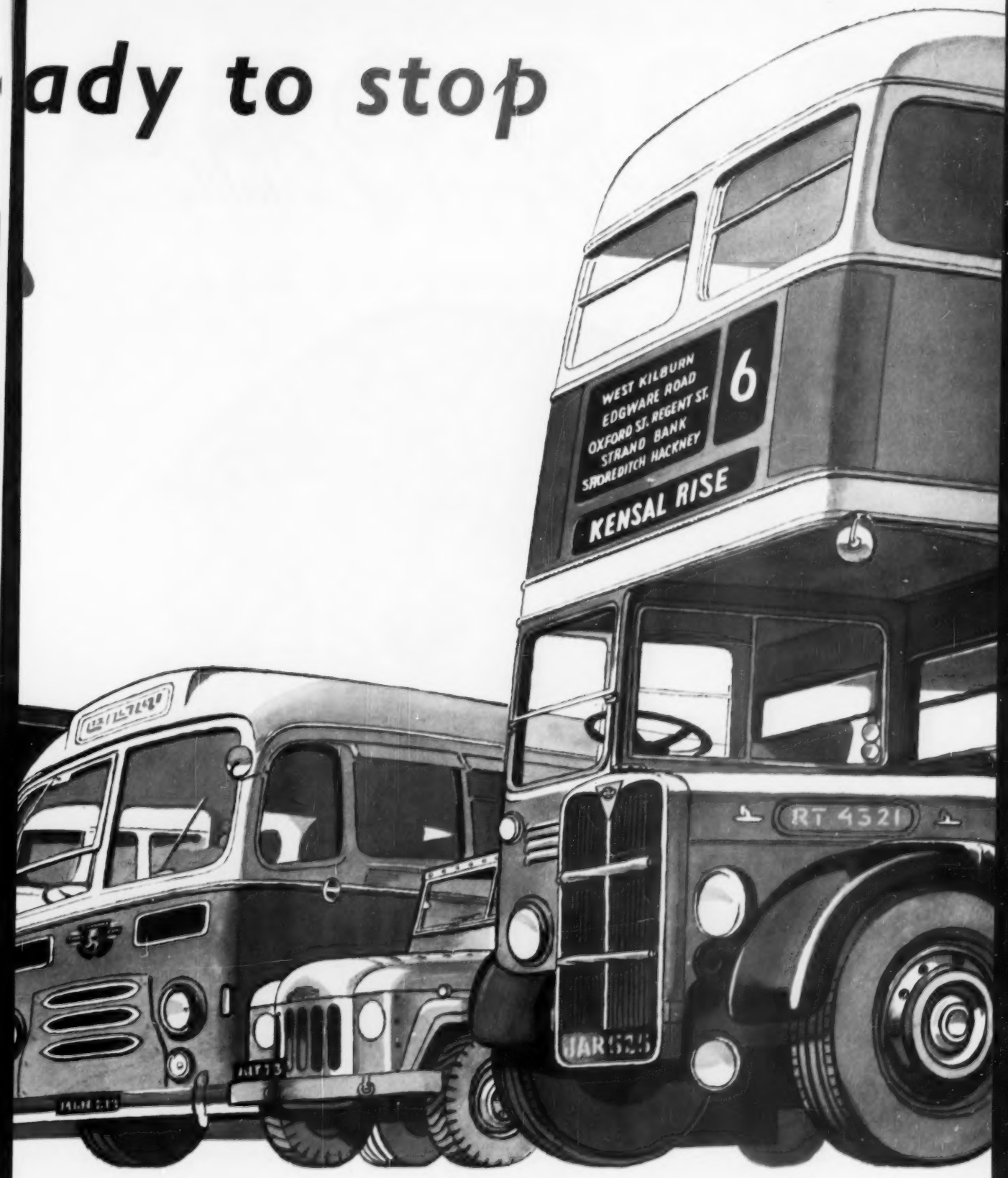

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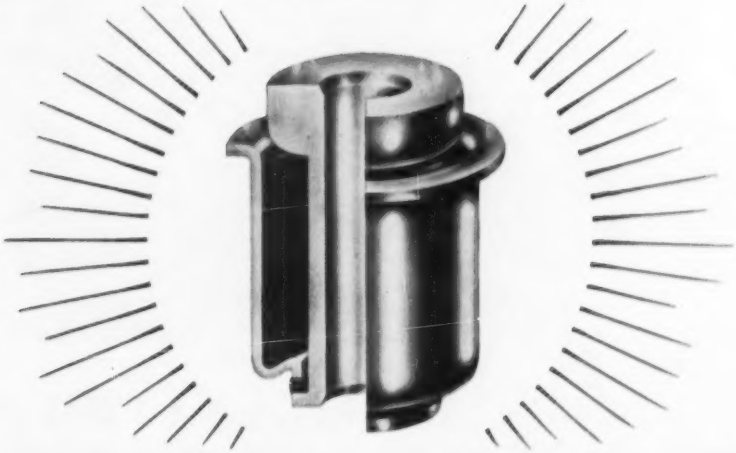

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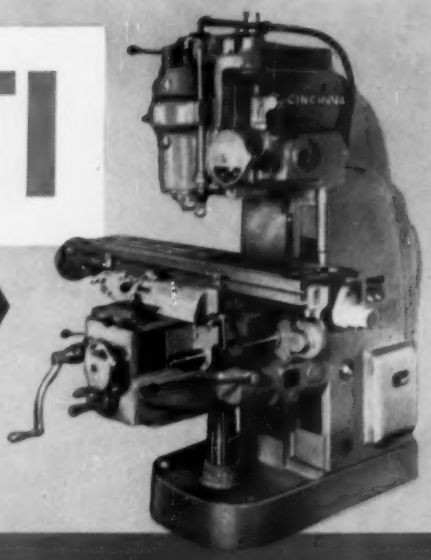

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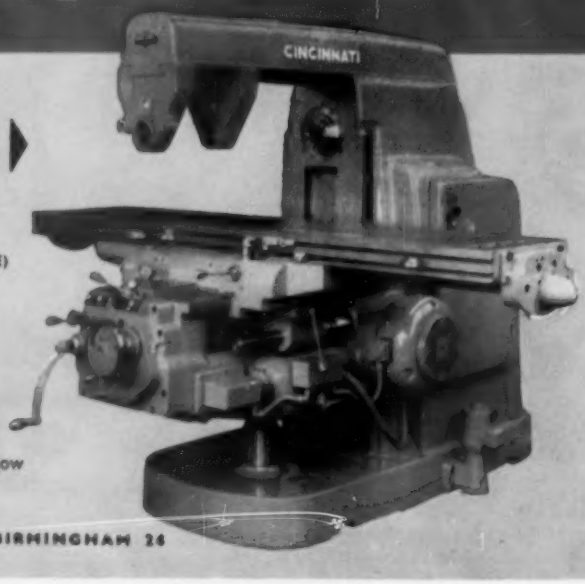

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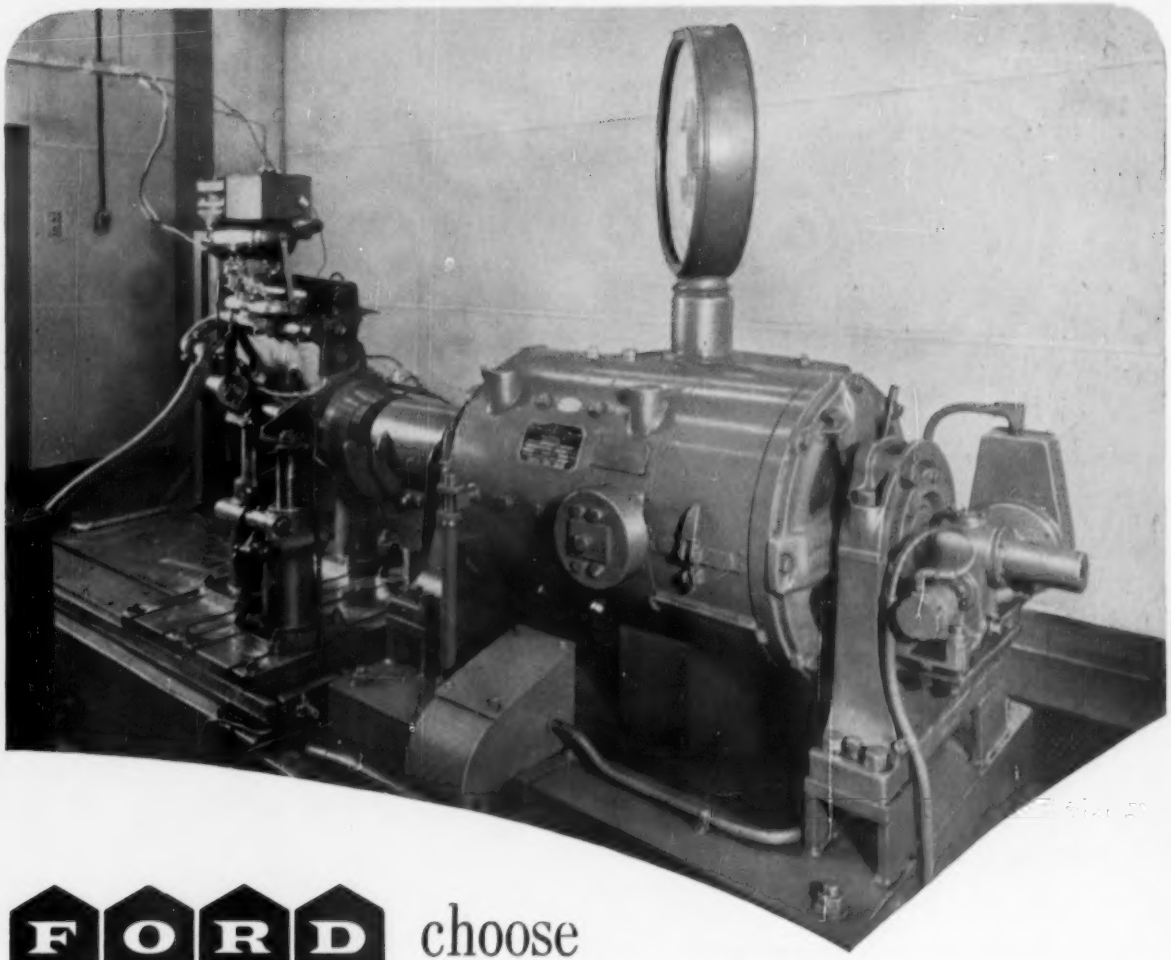

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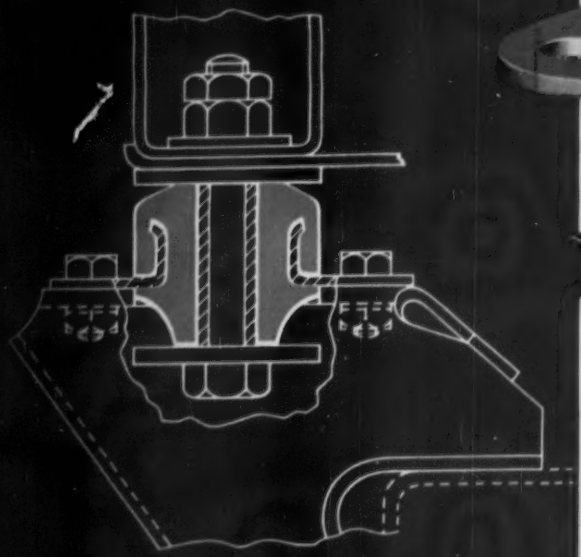

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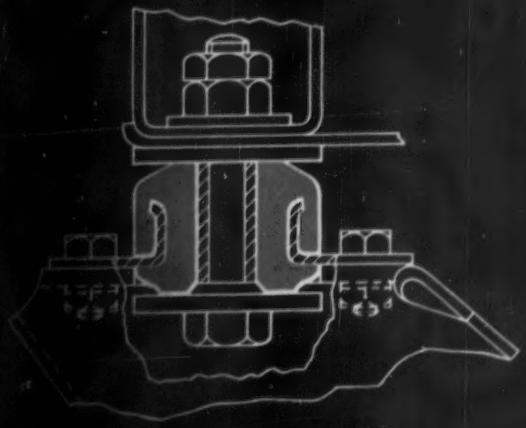

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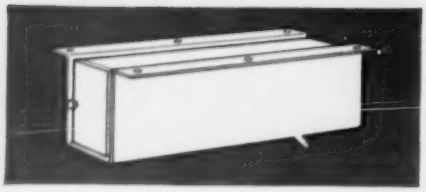

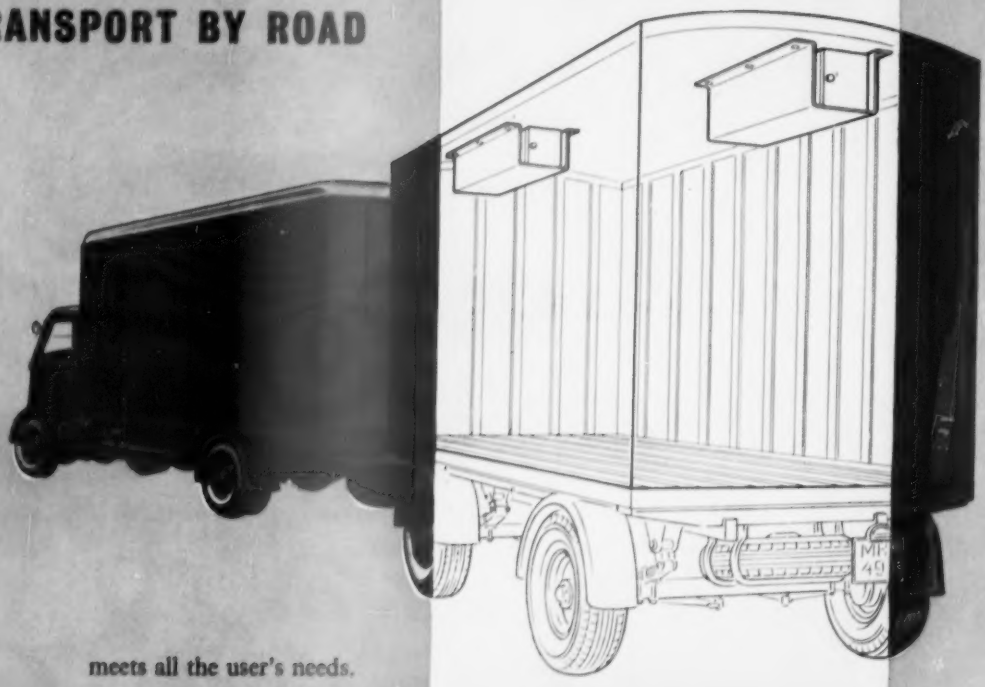

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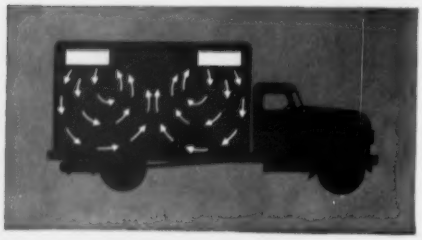

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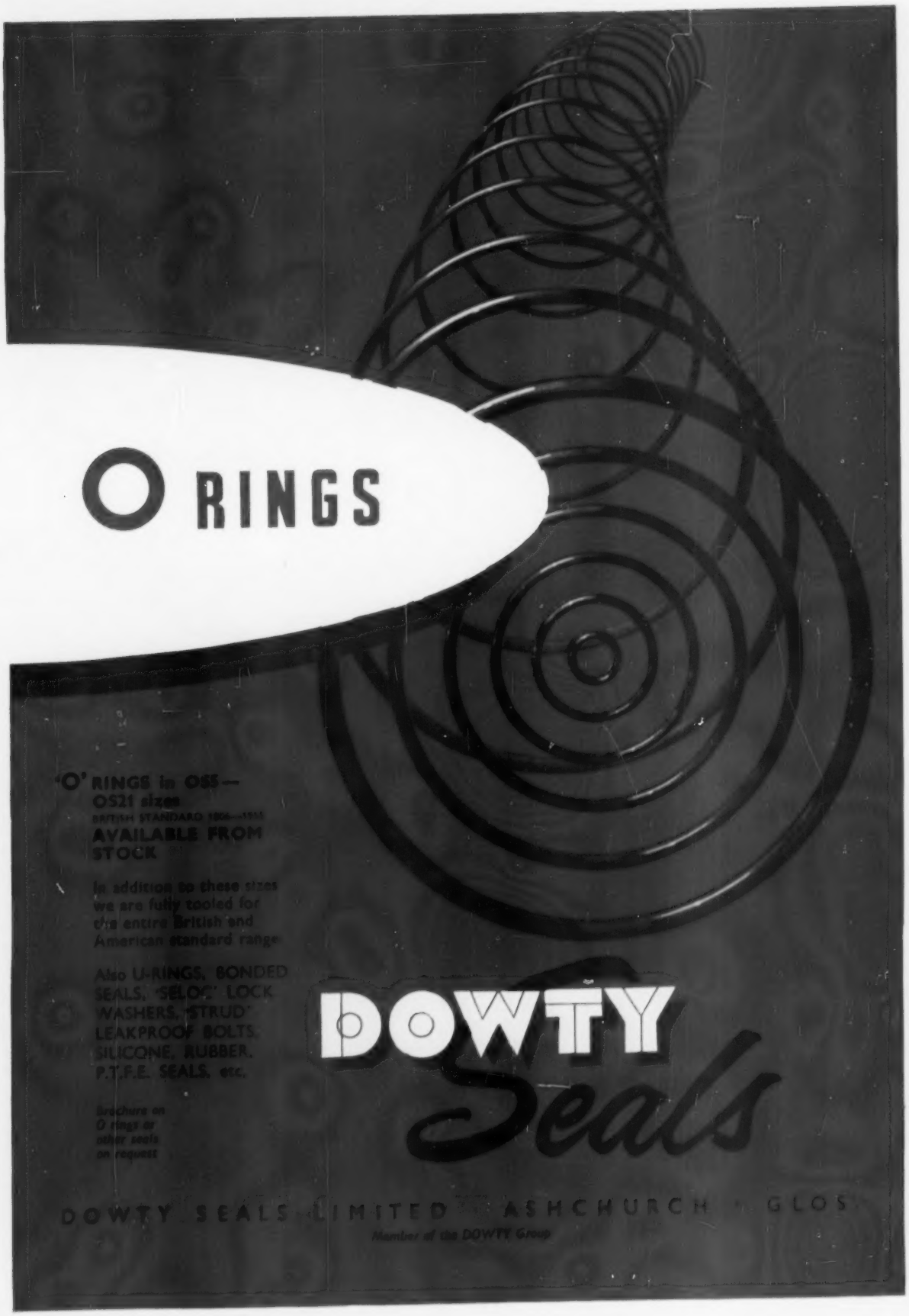
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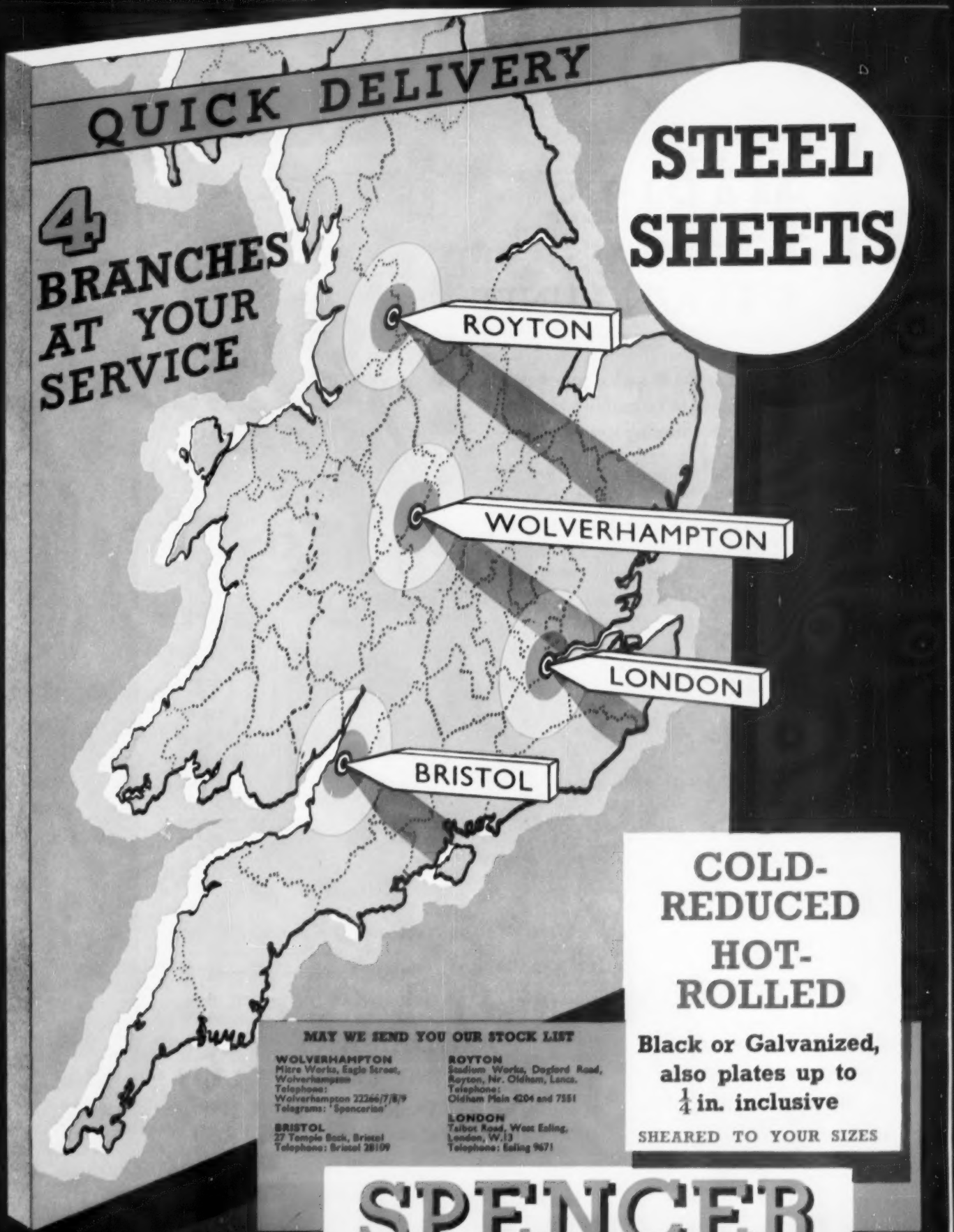

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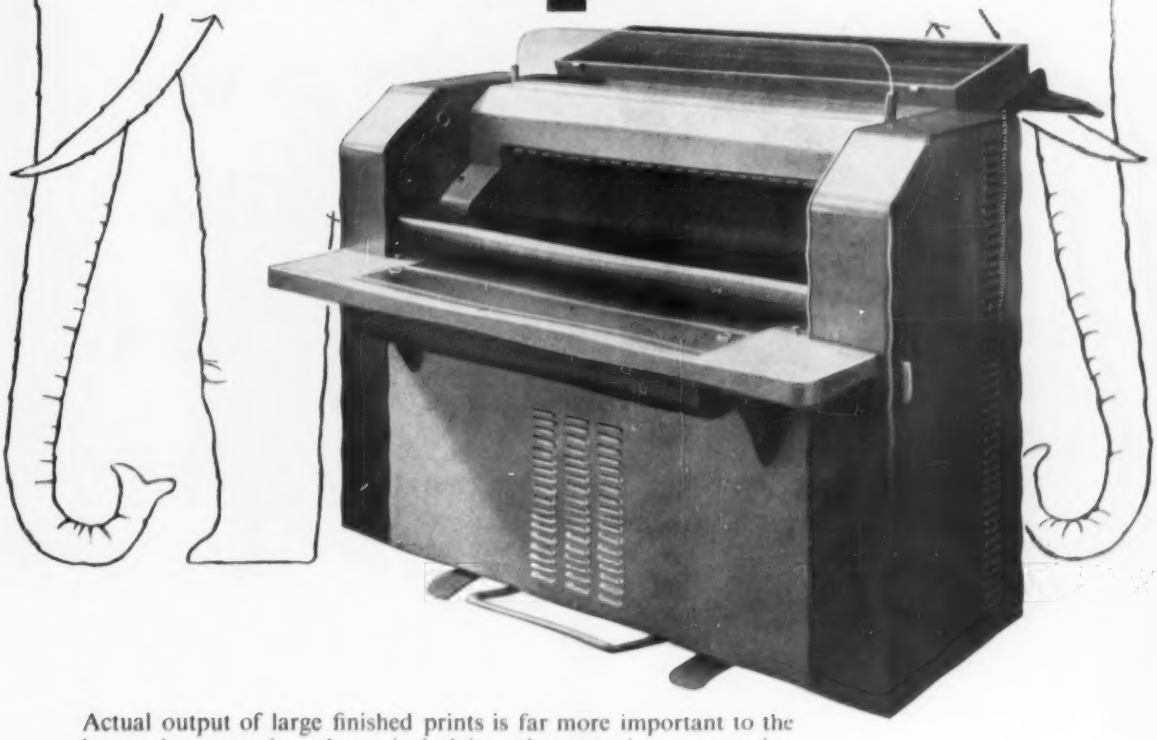

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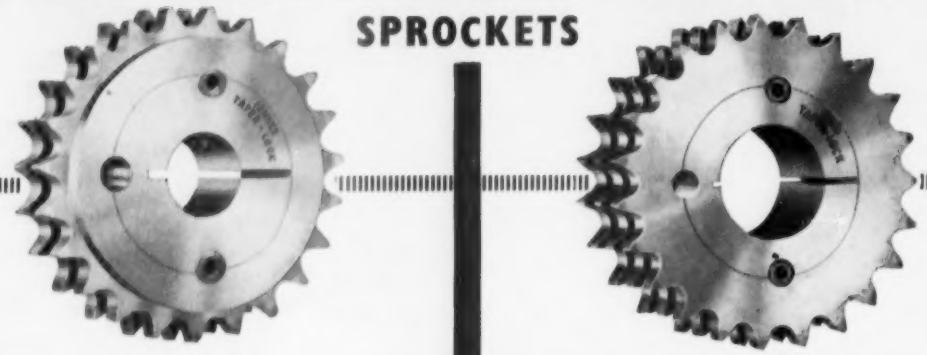

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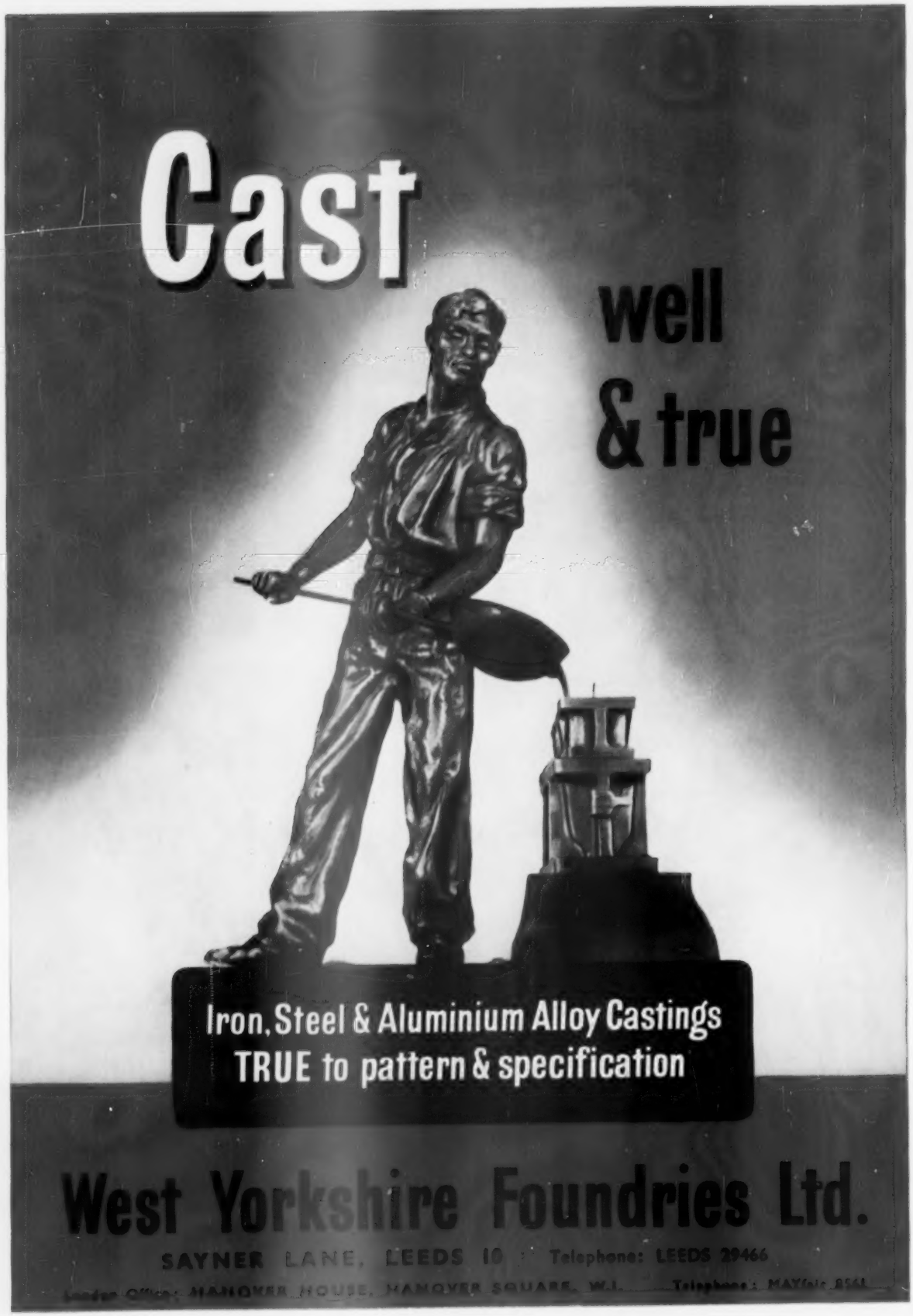
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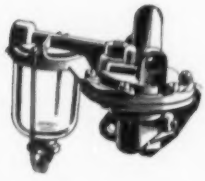

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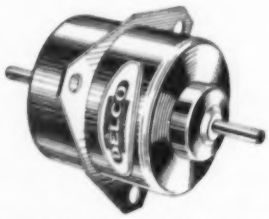

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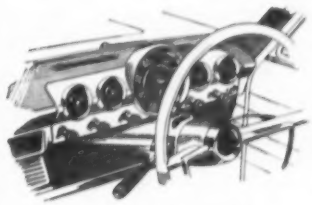

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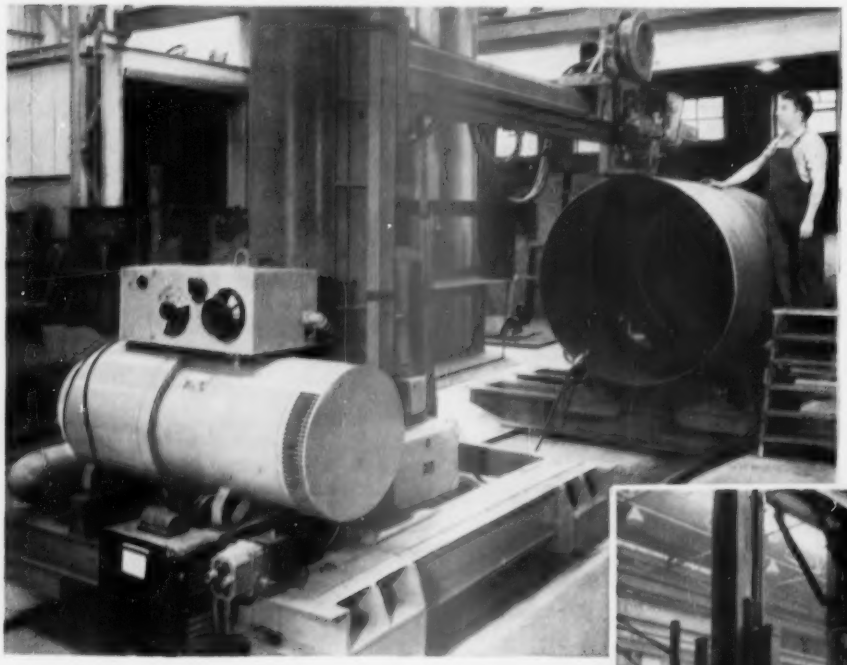
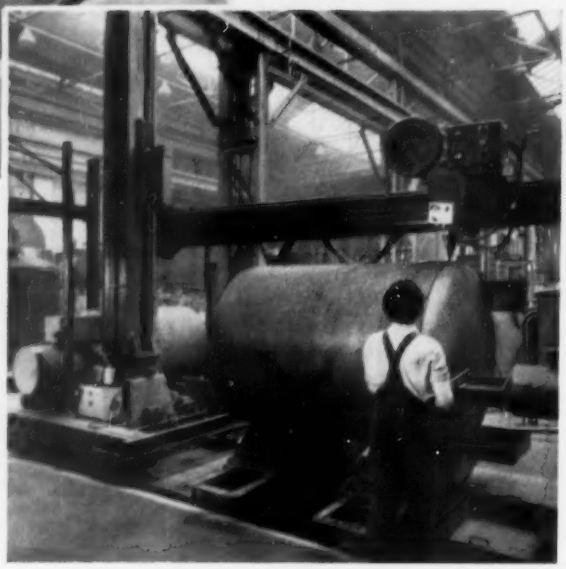


Lincolnweld at work. A 4' 6" diameter Air Receiver being circumferentially and longitudinally welded. This is one of a series of similar Receivers which will form part of a new Vauxhall Motors automation set-up at Luton. Lincoln 780 flux and wire are used for the longitudinal seams and dished ends.



Under 4 years ago, the Empyrium Welding and Manufacturing Co. Ltd., of Birmingham employed hand Arc Welding, and only one Lincolnweld ML-2 Semi-Automatic welding machine. Since the recent installation of a new Lincolnweld Fully Automatic head, practically all the Pressure Vessels and Air Receivers produced in their works are completely fabricated by the Fully Automatic process to satisfy the exacting requirements laid down by the Petroleum and Chemical Industries.

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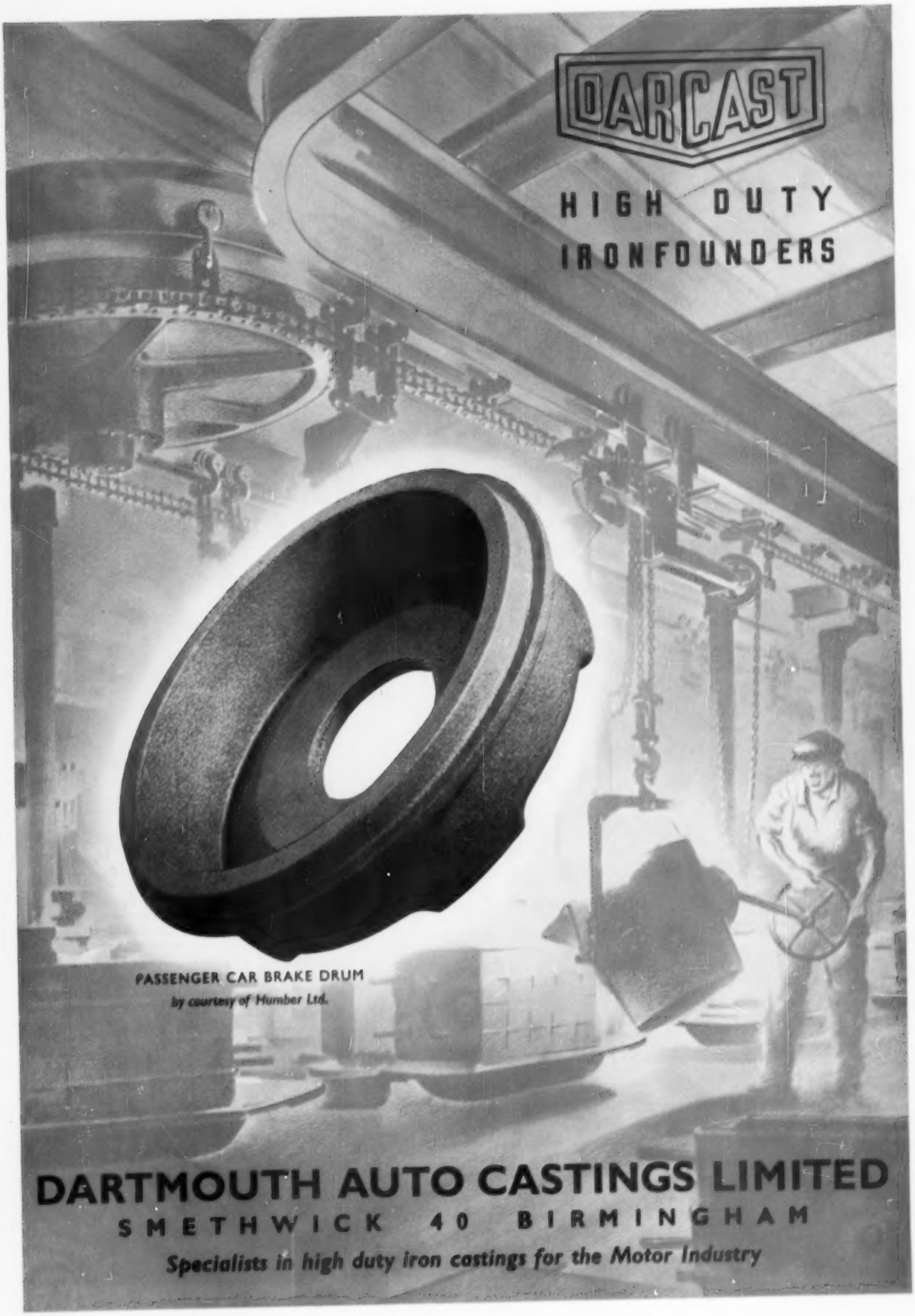
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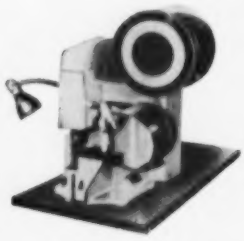

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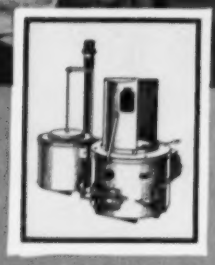

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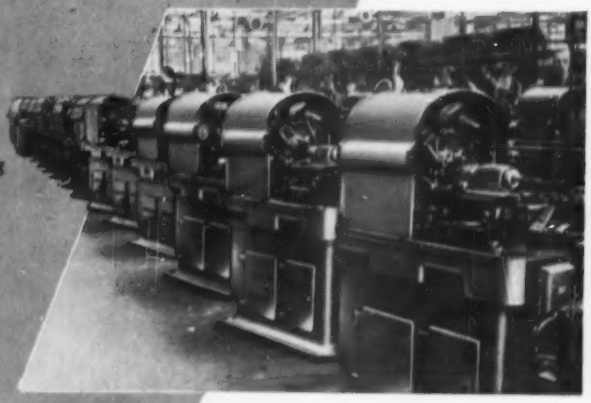

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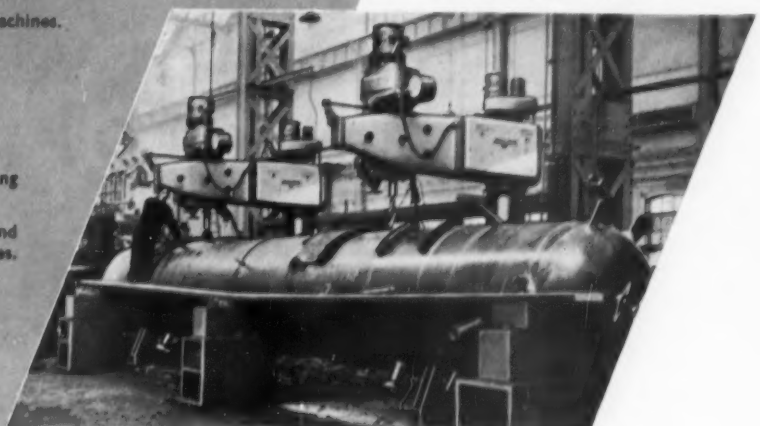

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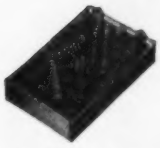

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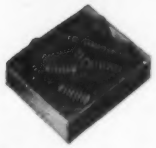

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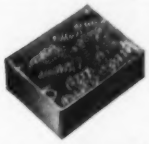

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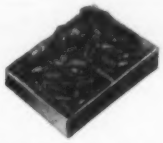

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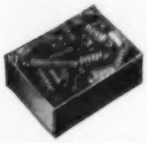

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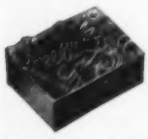

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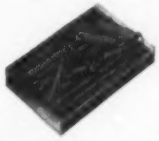

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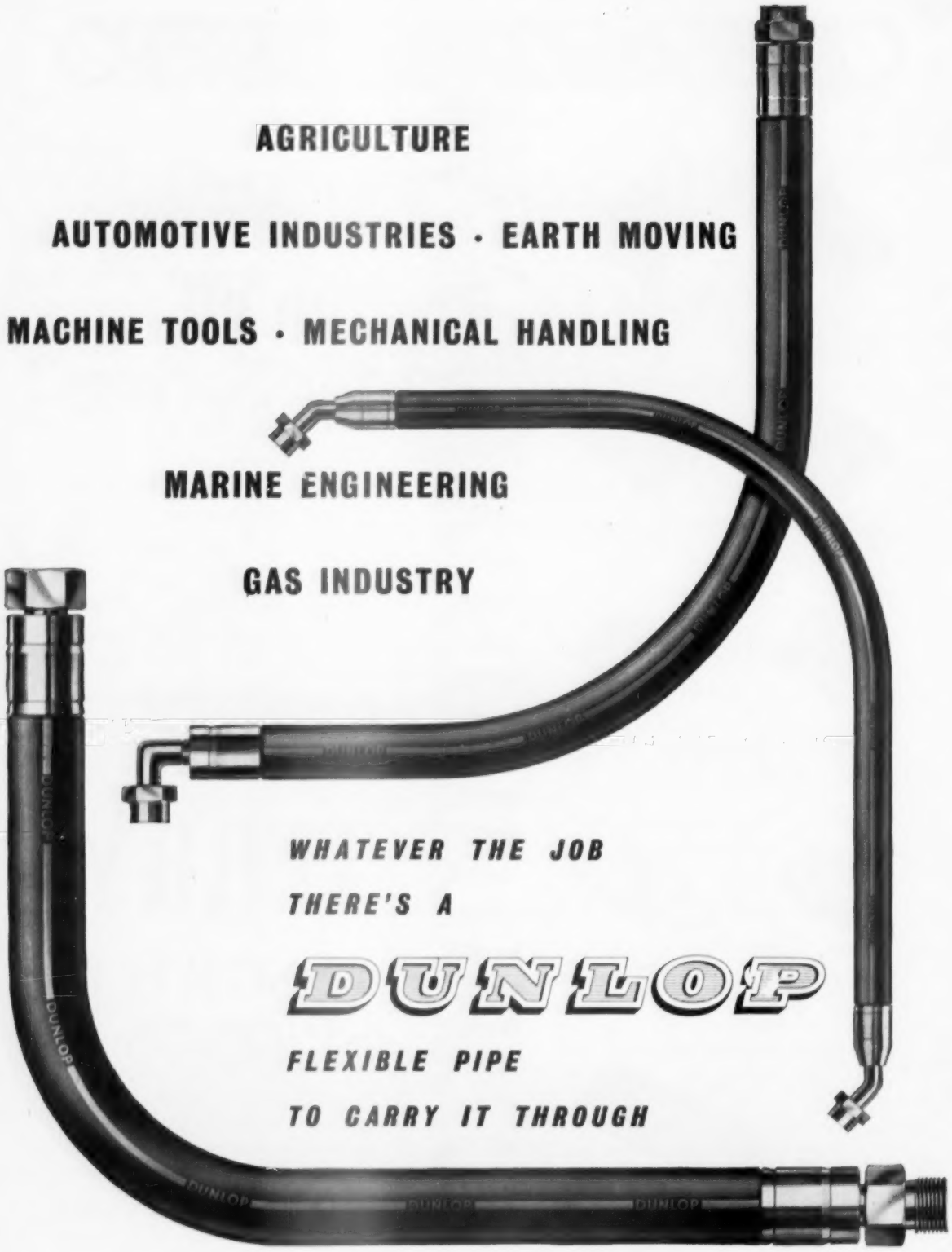

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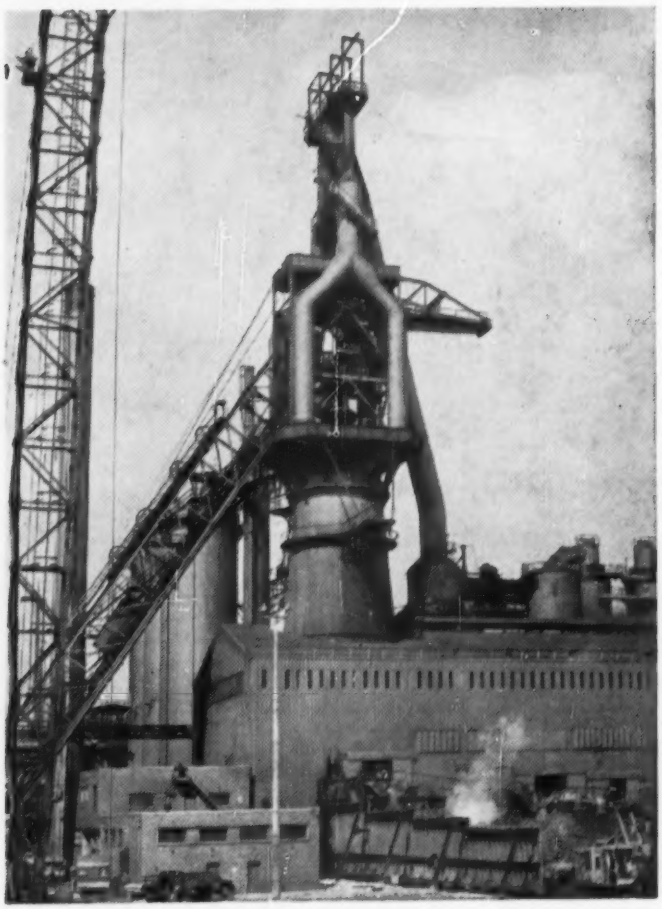

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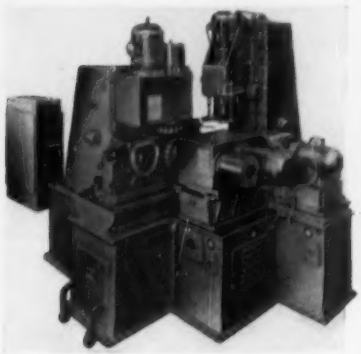

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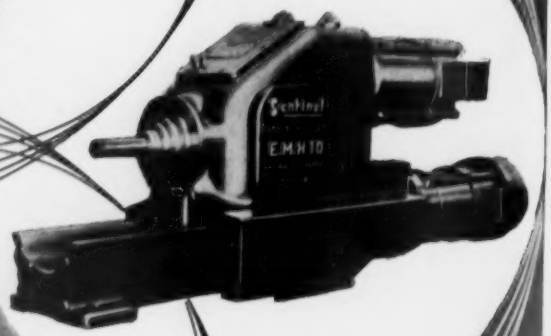

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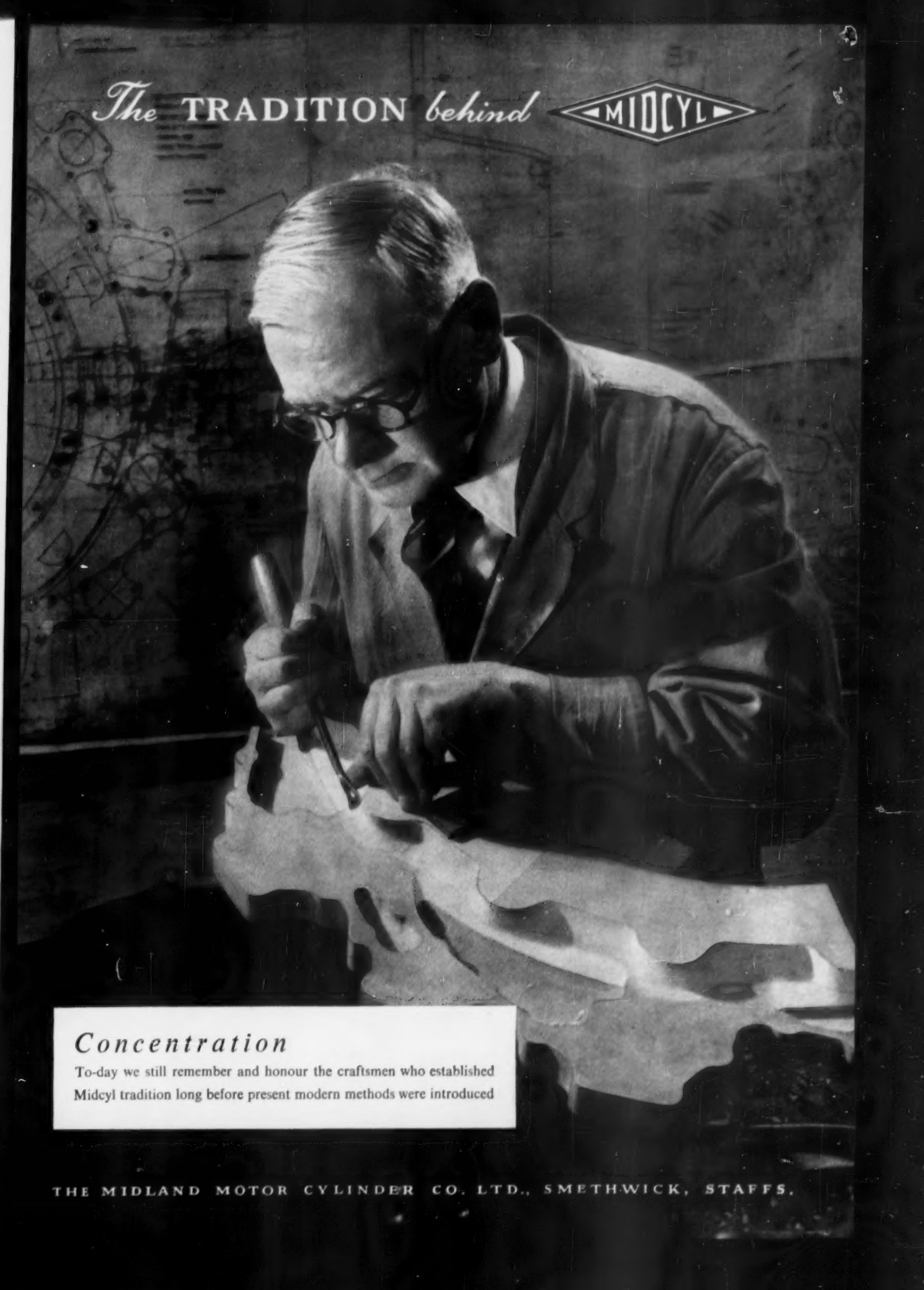
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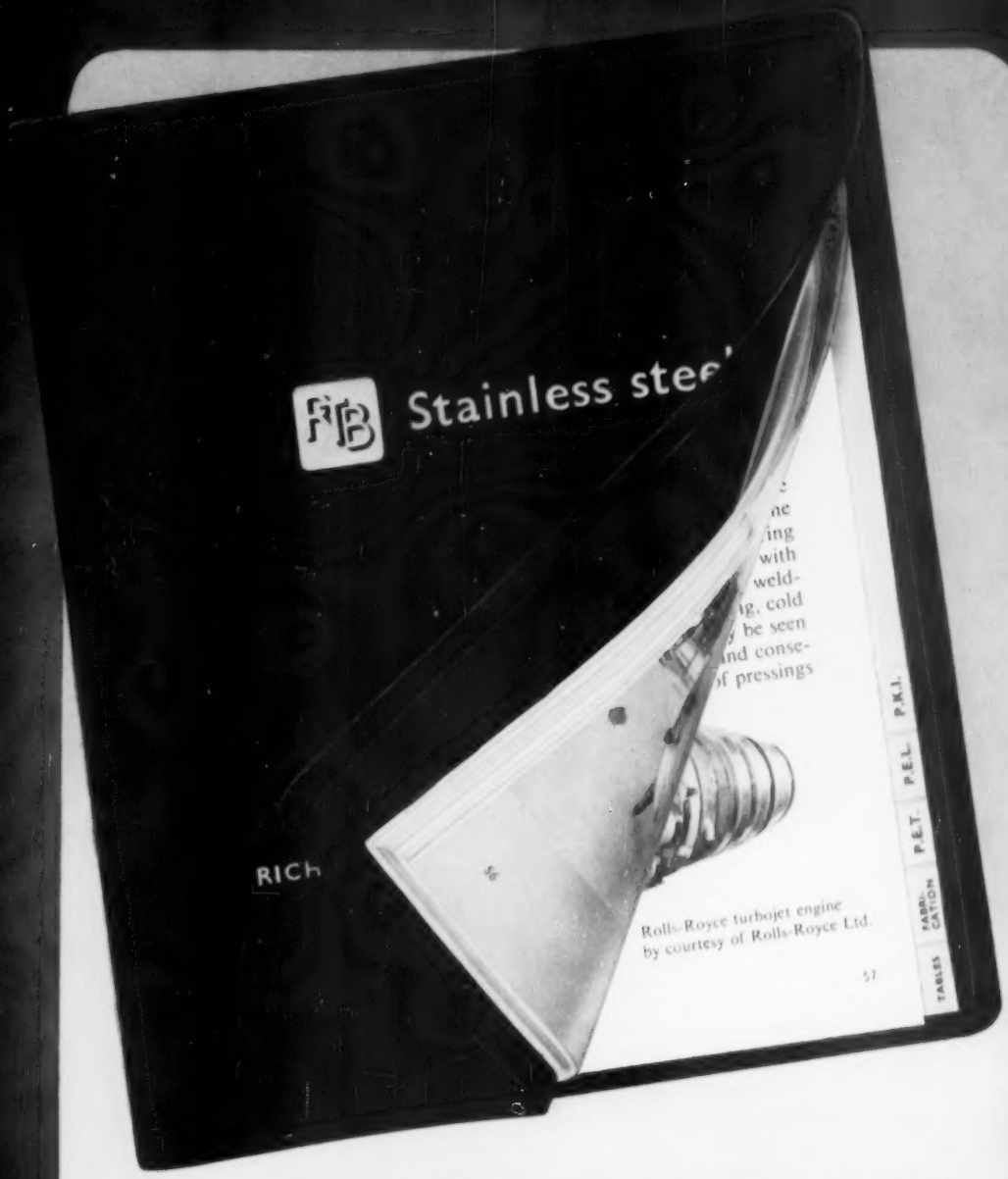

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AUTOMOBILE ENGINEER

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Published the second Wednesday in every month by ILIFFE & SONS LIMITED
Dorset House, Stamford Street, London, S.E.1.
Telephone · Waterloo 3333 (60 lines)
Telegrams · Sliderule, Sedist London.
The annual subscription inland and overseas is £2 17s. 0d. including the special number Canada and U.S.A. $8·50

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VOLUME 46 **NUMBER 13** **DECEMBER 1956**

The Conquest of Friction

In a bas-relief found at Nineveh there is shown the transport on skids of a huge sculptured stone; a horde of slaves pull on ropes while others assist with a large lever at the rear. The most interesting feature of the bas-relief, however, is the clear depiction of spoked wheels in the handcarts which are bringing up the tackle — wheels which appear to be the same in essential detail as the wheel of today, and a great advance on the solid disc hacked from a log.

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DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Spot-Welding

WITH the continued trend towards the widespread adoption of chassisless construction, the importance of spot-welding processes in motor vehicle manufacture has, of course, greatly increased. Even in the heavier frames of commercial vehicles, resistance-welding in one form or another has to a great extent taken the place of riveting and bolting. Tests have shown that in most applications spot-welded joints are as good as riveted ones so far as both fatigue and static strength are concerned. Since resistance-welding equipment is more complex than that used for riveting, careful attention must be devoted to its maintenance, otherwise satisfactory results cannot be obtained consistently.

The fact that spot-welding has taken the place of riveting has led to a tendency for spot-welding machines, particularly of the hand-gun type, to be treated in much the same way as the riveter's tools; that is, they are used until components wear or break and then they are simply repaired and put into service again. This, of course, is a wrong approach: welding machines need systematic attention. The electrodes in particular should be replaced at regular intervals by properly serviced ones and, while on the machine, they should not be filed by the operator. It is also desirable that the mechanical pressure, the current, the time cycle, and the electrode size should be closely controlled. Fortunately, the steel used in body construction is of the type that allows considerable latitude in these respects; however, this might encourage carelessness. There are, of course, limits beyond which, even with the best welding steels, it is not possible to obtain consistently good joints. Most users of resistance welding equipment are aware of these, but there are still some whose welding standards are not good.

The fact that the structural strength and reliability of modern vehicles are so dependent on sound welded joints is one of the strongest arguments for the better control of spot-welding. Resistance to fatigue can only be obtained by uniform pitching of the welds and by consistency with regard to their shape, size and quality.

Incorrect adjustment of the machine is the commonest cause of poor spot-welding. It is doubtful if the introduction of a satisfactory scheme for the maintenance of the welding machines adds much to the cost of production, for the alternative at present adopted in many instances by operators is to make more spot-welds than would be necessary if each of them could be relied on to take its proper share of the load. In the interest of economy it is necessary not only for the welding conditions and process to be controlled, but also for the designers to specify the size and pitch of welds to be applied, rather than to leave these to the discretion of the operator. In some instances, the spot-welds specified are too small to give optimum results so far as strength is concerned.

The advent of the multiple-head spot-welding machine has simplified accurate pitching of welds. It has also led to better welding, because there is a tendency for the maintenance of expensive machines of this type to be taken more seriously than that of the small and relatively inexpensive hand-gun types of equipment. Some manufacturers instal counters on their machines which, when a certain number of spot-welds have been effected, sound a buzzer to indicate that the electrode must be changed.

Other features essential to good welding include, of course, attention to both the preparation of the material and the accuracy of manufacture of the mating parts. So far as the preparation of the material is concerned, the adverse effect of thin films of oil is not great enough to warrant de-greasing; however, rust or scale should be removed. This problem does not arise to a great extent in the motor industry, because bright steel is widely employed. Moreover, the material is used almost immediately it is delivered, so normally it does not have time to rust.

Fortunately, the hand-gun type machines are rarely powerful enough to force together mis-shapen sheet metal components, so the design of press tools for the accurate production of these components receives careful attention. Nevertheless, there is a tendency for relaxation in this respect where the more powerful multiple-head machines are employed. This is a tendency that must be guarded against, not only because the result is bad welding, but also because components that are forced together in this way are, of course, pre-stressed, and in many instances the loading thus applied to the welds and to other parts of the components is such as to cause local stress concentrations not catered for in the design.

An opportunity of designing for spot-welding of a quality hitherto almost unobtainable with semi-skilled labour has been provided by development of press type multi-head welding machines. It is now relatively easy to obtain accuracy with regard to both the pitch of the spots and the control of welding conditions. This opportunity should be grasped, so that a marked improvement in the standard of welding can be gained, in addition to the economic benefits of higher productivity.

The four-seater Goggomobil car is more stylishly designed than most miniature cars

MINIATURE CARS

Some European Interpretations of the Design Problems of this Class of Vehicle

SINCE the war, there have been many attempts to produce miniature cars, powered by engines of less than about 600 cm³ swept volume, but few have been successful. The market for this type of vehicle is smaller than that for more conventional cars, so tooling for production in large quantities to reduce the price is a great risk. On the other hand, unless the price is appreciably lower than that of conventional cars, the demand is inevitably smaller still.

Styling is extremely difficult because the overall dimensions of the vehicle must be kept to a minimum to avoid unnecessary expense, while the size of the people that it must be designed to accommodate is, of course, an unalterable factor. Thus, it is difficult to give the vehicle a long sleek appearance because, in order to keep the overall length to a minimum, the seat squab angle has to be nearly vertical, and this increases the height of the roof. When so much of the available space is taken up by the passengers, there is not much room for luggage; and even if there were, the engine is scarcely adequate to take any extra load. Light weight is essential, but this must be obtained without increasing the cost of construction.

Despite these handicaps, some of these vehicles are surviving in the face of competition from both small cars of more conventional design and two-wheeled vehicles. They have gained ground in fields of application in which motor scooters hitherto have been operating unchallenged. For example, on the Continent, ladies use motor scooters extensively for shopping and taking children to and from school. However, these vehicles do not afford adequate protection in cold or wet weather and they have not suitable accommodation for bulky parcels. Accordingly, one or two manufacturers have sought to overcome these disadvantages by developing miniature cars designed to seat two people in tandem.

Although cars of this layout can be produced at the lowest possible cost, customers generally demand something better than a two-seater, so a number of vehicles capable of carrying three, and in some instances four people, have been evolved. There is a tendency to draw a comparison between these vehicles and larger cars. Of course, such a comparison is most unfavourable to the miniature car and is also unfair because the miniature car is in a class of its own and is suitable for a limited field of applications, in which small size, and low first cost and running expenses are the prime considerations.

Isard 300

The Isard 300 Goggomobil is manufactured by Hans Glas G.m.b.H., Isaria Maschinenfabrik, Dingolfing, Bavaria. It is a four-seater vehicle driven by a 293 cm³ two-cylinder two-stroke air-cooled engine installed at the rear. Its overall dimensions are: length 9 ft 6¼ in, width 4 ft 2½ in and height 4 ft 3½ in, and the ground clearance is said to be just over 10 in. The dry weight is 850 lb. A wheelbase of 5 ft 11 in has been adopted, and the track is 3 ft 6¾ in.

Inside, the dimension between the clutch pedal and the centre of the rear seat squab is 53 in and between the dash facia and the same part of the rear seat squab it is 49 in. Between the rear face of the squab of the front seat and the front edge of the cushion of the rear seat, the distance is 9 in, and the front edge of the rear seat cushion is 13 in from its squab. From the centre of the floor to the roof, the dimension is 41½ in. The width, at waist level, between the

This pressed steel, platform type frame is employed in conjunction with the steel body, which is welded to it, to form the load-carrying structure of the Goggomobil

door-hinge pillars is 41 in, and between the body panels on each side of the rear seat it is 49 in. Above the front seats, the width between the door trim panels is 44 in. The distance between the front wheel arches, measured at the toeboard level, is 28¾ in.

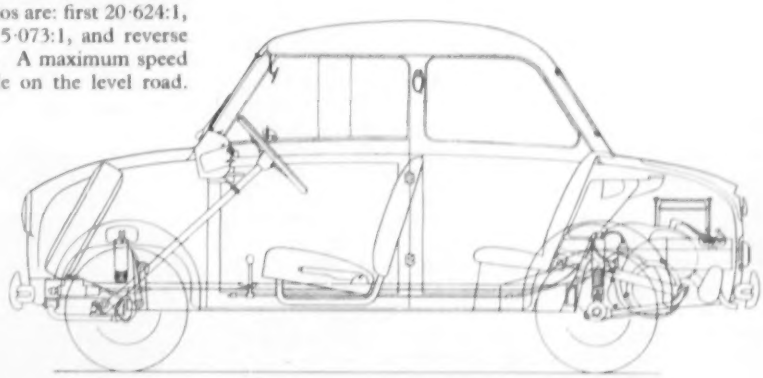
The vehicle is powered by the Isario two-stroke engine, designed by Adler. Its bore and stroke are 58 mm and 56 mm respectively and the compression ratio is 6·5:1. The unit develops 17 b.h.p. at 4,800 r.p.m. and its maximum torque of 17·3 lb-ft is obtained at 3,800 r.p.m. Lubrication is effected on the petroil principle and the mixture ratio of oil to petrol is 1:25. Fuel is fed to the carburettor by gravity. A 130W dynamo is employed, together with an 18 amp-hr battery and an electric starter. Warm air from the engine cylinders is taken through an aperture in the heelboard to heat the interior of the car. In addition, air is ducted from the blower that supplies cooling air to the cylinders, through a pressed steel jacket fitted over the exhaust pipe, to the windscreen demister slots.

A twin-disc oil-bath clutch transmits the drive from the engine to a conventional four-speed gearbox, which is housed together with the differential in a single casting. The layout is interesting in that the aluminium casing for the crankshaft and transmission is divided horizontally, and all the shafts except that for the reverse idler pinion are in the same horizontal plane. Constant mesh dog engagement gears are employed. There are substantial thrust faces on each side of the crown wheel assembly, to take the side loads from the rear wheels. The gear shift lever is mounted centrally on the floor and the overall ratios are: first 20·624:1, second 10·996:1, third 7·177:1, fourth 5·073:1, and reverse 18·05:1. The final drive ratio is 55:16. A maximum speed of 59 m.p.h. is claimed for this vehicle on the level road.

The vehicle is of semi-chassisless form. It comprises a pressed steel platform type base-frame with a steel body shell welded to it. Channel sections are pressed longitudinally along each side of the platform floor to form the sills, and mid-way between them a large top hat section pressing is spot welded by its flanges longitudinally on the platform. This central member, which is attached at each end to cross members, provides the torsional stiffness of the base-frame. Two top hat section cross members are spot welded by their flanges to the floor underneath the front seats. They extend the full width between the sills, but are broken at the centre to accommodate the backbone component.

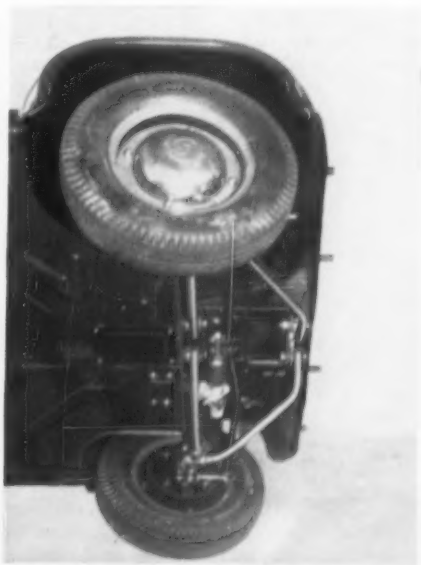
As can be seen from the accompanying illustration, the floor has long rectangular-shaped, dished sections pressed in it; they are arranged herring-bone fashion on each side of the central backbone member. This is to stiffen the panels and prevent the generation of noise. The wheel arches are welded in cut-outs at the four corners of the platform. At the front, the floor is stepped up, to act as a cross member, and then slopes forwards again to form the toeboard. Forward of the toeboard, it is again horizontal, and its extreme front edge is flanged downwards to form another deep cross member. An inverted top hat section is spot welded under the toeboard and forward extension, to form a box section longitudinal member, and carries the pivots of the divided axle front suspension units.

The construction at the rear is slightly more complicated



Longitudinal section of the Goggomobil, showing the general arrangement of the seating and mechanical components

Left: Swing axles are used in conjunction with leading links on the rear suspension of the Goggomobil



Right: A divided axle front suspension system is employed and the drag links are pivoted forward of the axle

Interior arrangement of the Goggomobil, showing the front squab pivoted forwards to give access to the rear seats

because it carries the engine. A cross member is formed by a deep top hat section, which is raked rearwards and spot welded by its flanges to the floor. The front face of this cross member is the heelboard. At the centre, it is cut to fit over the backbone member, to which it is welded. The rear end of the backbone is closed by a plate with a hole in it to carry a rubber ring round the gearbox extension. This ring forms the front mounting for the power unit and transmission assembly. The other two mountings are on a channel section cross member behind the engine. This cross member is welded to the ends of two tubular cantilevers that extend rearwards from the main cross member. These tubes are passed through holes in the front and rear walls of the main cross member, in which they are welded.

Fabricated pressed steel horn-shaped arms are welded on top of each end of the main cross member. They overhang to the rear to carry the suspension coil springs and telescopic shock absorbers, which are mounted coaxially. The rear suspension is of the swing-axle type. There is a universal joint at the inboard end of each axle, and the motion of the wheel hubs is constrained by links, pivoted between lugs on the ends of the channel section cross member that carries the rear mountings of the engine. The axes of the pivots are in line with the centres of the universal joints. On each side, the lower end of the suspension spring seats on top of the wheel hub assembly.

At the front, each half of the divided axle comprises two main tubular components, one being the transverse link and the other a drag link swept forwards and pivoted well in front of the transverse link. The pivots of both links are, of course, in line and their axes are parallel to the longitudinal axis of the vehicle. At their outer ends, the tubes are fitted into a socket joint. The lower end of the coaxial spring and telescopic hydraulic shock absorber assembly on each side is mounted on this socket component and its upper end is secured to a bracket attached to the wheel arch and the toeboard. All four wheels are equipped with 4·40—10 in tyres. A rack and pinion steering unit and the brake, clutch and throttle pedals are mounted on the cross member formed by the step at the junction between the floor and the toeboard. The inner ends of the two-piece track rod, which is not adjustable, are both attached to one end of the rack. This is because the pivots of the swing axles are so close together.

Soletta

A number of unconventional features have been incorporated in the Soletta, the prototype of which has been designed and manufactured in Switzerland by W. Salzmann, of Solothurn. The vehicle, as shown for the first time at the Geneva Show early this year, was designed primarily as an operational test bed for the new design features that it incorporates. Therefore, the emphasis, up to that time, had been on functional design rather than styling. It was announced that should any manufacturers wish to undertake full scale production of the vehicle, they no doubt would wish

The latest version of the Soletta car, as exhibited at the Paris Motor Show in September of this year, is but little changed mechanically

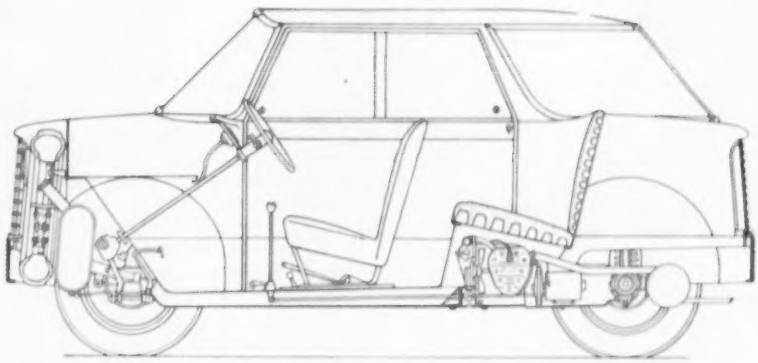
This is the original version of the Soletta car, as exhibited at the Geneva Motor Show in March 1956. It was designed simply as a mobile test bed for the development of the new ideas that it embodies, and therefore styling was not seriously considered by the designers

to incorporate their own style and so would modify the layout accordingly. Since then, at the Paris Show, a restyled version has been exhibited. A noteworthy feature of the design is the fact that almost the whole of the length between the extreme front and rear ends is used for carrying the passengers and luggage, since the engine is under the rear seat.

The overall dimensions of the vehicle are: length 9 ft 10 in, width 4 ft 4½ in, and height 4 ft 6½ in. A ground clearance of 7·1 in has been obtained and the turning circle diameter is 26 ft 4 in. A wheelbase of 6 ft 7 in has been adopted and the track is 3 ft 9½ in at the front and it is 3 ft 9¾ in at the rear.

Glass reinforced plastics has been used for all the body panels except the doors, which are of steel; support is afforded

A noteworthy feature of the Soletta is the way in which almost the whole of the length of the vehicle is available for passengers and luggage. In most other designs, the engine takes up the space either under the bonnet or in the boot



by a welded steel framework, on which the plastics is moulded. The front and rear end body panels are identical, as also are the two doors, one of which is hinged on the front pillar and the other on the rear. In addition, the four wheel arches are common. An unconventional layout has been adopted. At the extreme front end, the spare wheel is carried immediately behind the dummy grille. The petrol tank, which is of deep section so that it does not occupy a great deal of the length of the vehicle, is behind the spare wheel. Between the tank and the toeboard are the front suspension, steering and pedals. Above the toeboard, there is an exceptionally large, horizontal shelf to take parcels. Its front edge is curved so that, at the centre, the length between its front and rear edges is 20 in and, at each side, 24 in. Between the shelf and the scuttle the distance measured vertically is 10 in. This enables space that would otherwise be wasted to be used.

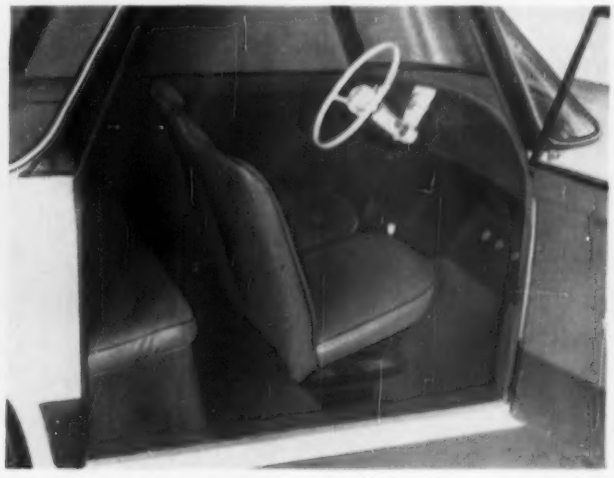
Two bucket type seats are fitted for the driver and front passenger, and there is a bench type seat at the back. The engine, installed under the rear seat, is mounted in unit with a gearbox and differential unit. A single dry plate clutch transmits the drive to the gearbox and differential unit. The differential is behind the gearbox. This unusual arrangement has been adopted to suit the engine position: normally, with either the rear-engine or front-wheel-drive layouts it is necessary, of course, to have the differential between the clutch and the gearbox. A modified form of swing axle suspension is undergoing development. Above the final drive and rear suspension assembly, the whole of the space between the squab of the back seat and the rear end of the vehicle is available for luggage.

Above the front seats, the width at the waist is 43 in. At elbow level, that is, between the outer panels on which the trim is stuck, the width is 49 in. The rear seat squab is curved. Its cushion is 50 in wide, by a maximum of 18 in from front to rear. From the centre of the rear seat squab to the scuttle, the dimension is 54 in. Between the front edge of the rear seat cushion and the back of the front seat squab, the distance is 9 in. There is no dash facia. Instead, a single instrument, the speedometer, is mounted on a bracket, which also serves as a brace between the scuttle and the steering column.

The doors are 42 in wide, so access to the rear is obtained easily without tilting the front seat forward. Each has two horizontally sliding window glasses that overlap slightly at the centre. The rear light comprises two curved transparent panels, with a centre pillar; in appearance, it is not unlike the early post-war Studebaker models, which were among the first quantity produced cars to have large, curved rear lights. The all-round visibility is exceptionally good for such a small car.

A rack and pinion steering layout has been adopted. The

Views of the interior of the Soletta car exhibited at Geneva. Left: The rear seat cushion can be removed to give access to the engine. Right: Wide doors are employed so that access to all four seats can be readily obtained



front suspension layout is similar to that of the Renault 4CV; it comprises double transverse wishbone links with a coil spring and rubber assister spring. The wheels also are of Renault manufacture. Damping is effected by telescopic hydraulic shock absorbers.

It is the rear suspension that is one of the most interesting features of the vehicle. As has already been mentioned, the engine, clutch, gearbox and final drive are mounted in unit, one behind the other, that is, with the final drive at the rear. The front end of the engine is mounted on two rubber bushes, the axes of which form an obtuse-angle V in a transverse vertical plane. Thus, the whole unit tends to pivot about its front end as the rear end rises and falls with the suspension.

The swing-axles have been modified, by the incorporation of pendant brackets at the ends adjacent to the final drive unit, so that they each resemble a bell crank lever. A tie rod, with rubber springs at each end, interconnects the lower ends of the pendant brackets, and the rod is attached at its centre to the differential casing. The rate of the springs at each end of the tie rod is such that so far as low frequency vibrations are concerned, the swing-axles and final drive unit tend to move together as if the assembly were of the conventional through-axle design, but it is low enough to absorb vibrations at wheelhop frequency. Therefore, so far as wheelhop is concerned, the unsprung weight is almost the same as if a swing-axle system, with the final drive unit mounted on the frame, were employed. At the same time, so far as roll characteristics are concerned, the system tends to be more like a through-axle, except that the spring base is wider. Another advantage of the system is that in the static condition, the angle of the half shaft and wheel assemblies relative to the road and to the final drive unit remains constant, regardless of the load carried by the vehicle.

At the outer ends of the swing-axles, the coil springs and telescopic shock absorbers are mounted coaxially. Their axes are set at an angle such that they are in line with the centres of contact between the tyres and the road. This arrangement ensures that the weight of the vehicle is in effect applied directly over the tyre contact areas and therefore does not load the spring and rie rod assembly between the pendant arms at the inner ends of the swing-axles. Lateral location of the whole assembly can be effected either by a Panhard rod or, if this is too short, by a triangulated link, with its apex attached to the final drive casing and its ends pivoted on a frame cross member.

A great deal of development work remains to be done with this system and inevitably there will be difficult problems to be overcome. Some of these will be connected with the movement of the engine and gearbox about the pivot at the forward end of the assembly. However, these should not prove to be insuperable, since it is doubtful if the conditions are any worse for the engine than on a motorcycle without sprung rear forks.

There are a number of advantages to the layout, in addition to those theoretically obtainable with the suspension system. By mounting the engine under the rear seat, it has been possible to use space that would otherwise have been wasted, so there is ample room for luggage in the boot. The front: rear weight distribution is good; with two people in the front, the ratio is 54:46. In this particular vehicle, there is plenty of room inside, and the floor is unobstructed by a tunnel; therefore, if both of the front seats are removed, the owner can work on the engine from inside the car. Thus, he is protected from the weather and can take the full advantage of daylight by working with the car outside the garage. The rear seat cushion, like the rest of the vehicle, is trimmed with a plastics material so that it can be readily cleaned. Noise reduction might be a difficult problem. However, the area needed to be treated with insulating material is relatively small, since the engine is almost entirely enclosed in the box formed by the heelboard and seat cushion.

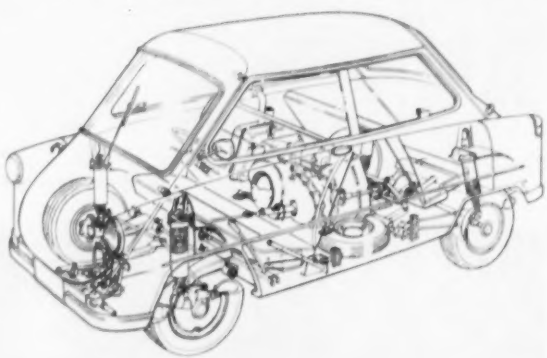
A Condor, horizontally-opposed twin-cylinder, side valve air-cooled engine is employed. It has been modified to suit the installation; for example, the exhaust ports are at the rear of the cylinders instead of at the front to improve the layout of the exhaust pipe and silencer. With a wet sump, the overall height of the installation was too great. Therefore, the sump was removed and replaced by a cover plate. The oil tank, or reservoir, is formed by a cross member of the frame and is situated immediately in front of the engine. Only one pump is employed; this scavenges the oil from the engine and forces it into the reservoir. The pressure built up in the reservoir feeds the oil back into the engine lubrication system. Again, development problems undoubtedly will arise.

The frame cross member that forms the oil reservoir, which is immediately below the heelboard, is shaped in such a way as to deflect the air flow up past the cylinders. Its cross section is a right-angled triangle, with the right-angle between the rear wall and the horizontal base. This member also acts as an oil cooler.

No doubt, insulation of the seat and heelboard, to prevent the transmission of heat into the vehicle when it is stationary for long periods in heavy traffic, will require attention. The problem would be eased by using shrouded cylinders with a blower for cooling, or by the employment of a water-cooled engine. However, both arrangements would add to the cost and there might be some difficulty in finding room for either a blower and shroud assembly or a fan and radiator.

The bore and stroke of the engine are both 78 mm, and

The seats are arranged back-to-back in the Zundapp Janus in order to make the best possible use of the limited space available



In the Zundapp Janus, the side panels are identical, as also are the doors at the front and rear ends. This appreciably reduces tooling costs. This arrangement also obviates difficulties with regard to access to the seats at both the front and the rear

the compression ratio is 6·3:1. A power output of 22 b.h.p. at 4,200 r.p.m. has been obtained. This represents 29·4 b.h.p/litre. The maximum torque is 31·8 lb-ft at 2,500 r.p.m. Two carburettors are employed and they are served by an electric fuel pump. The gearbox, which is the Renault 4 CV unit modified to place the differential at the rear, gives the following ratios: 17·45:1, 8·73:1, 5·05:1 and reverse 17·45:1. These, of course, include the final drive ratio of 4·72:1.

Zündapp Janus

Another interesting four-wheel vehicle of very small dimensions is the Zündapp Janus. A commendable feature of the design is the originality of thought that has been applied to it. The seating arrangement has been laid out in such a way that the available space has been used most economically; also, the design is to a large extent symmetrical, so that many of the body panels, both at the front and rear, and on each side, are interchangeable. These features have been obtained by the arrangement of the front and rear seats back-to-back and by incorporating a door at each end of the vehicle. The space between the seats is occupied by the engine, access to which is gained by folding down the squabs and moving the sound-proof cover. A spare wheel is stowed beside the engine.

The rear seats can be rearranged so that their occupants face forwards, but in this position, room is restricted and is really only adequate for children. In fact, there does not

Among the four-wheel vehicles with paired rear wheels, the Fulda-Mobil is, perhaps, most noteworthy on account of its modern styling

seem to be any good reason for turning the seats round, since the front and rear doors are identical and incorporate a windscreen; therefore the view from the rearward-facing seats is as good as that obtained by the passengers in the front seats. The advantage, so far as safety is concerned, of rearward-facing seats is obvious; this layout might appeal particularly to people who carry their small children in the back, provided the rear door can be locked securely.

Other seating arrangements can be adopted. For example, the rear seats can be removed altogether for the carriage of goods or very large quantities of luggage. The incorporation of doors at the front and rear ends is an advantage both in connection with the loading of luggage and also because of the ease of access to all the seats. When the vehicle is operated with four passengers, the luggage is stowed above the noise-insulated engine compartment. If the car is used for camping, all the seats can be laid flat above the level of the engine compartment to form a bed for two people. With this arrangement, luggage can be stowed underneath the beds so that it does not have to be left outside overnight.

So far as the exterior panelling is concerned, the only

The Fulda-Mobil is a two-seater, but at the back it has two folding seats, facing inwards, for small children

components that are not handed are the front and rear quarter panels, but they are small and of relatively simple form, so the cost of tools for their manufacture cannot be great. Because of the symmetrical disposition of the heavy components, a favourable front:rear weight distribution is obtained under almost all conditions of load.

It is stated that the fact that the front and rear track are almost equal helps to give a comfortable ride on rutted tracks, but undoubtedly this arrangement was adopted mainly for the sake of symmetry. The wheels are as large as practicable to reduce shocks, improve road holding and to give lower tractive losses. In many of the other small car designs, such large wheels are impracticable because they would encroach too much upon the space required for the doors. Some manufacturers of small cars have restricted their suspension deflection to save space and in some instances, particularly on three-wheeled or other vehicles with a narrow track, to improve stability. However, in this car, relatively soft springing has been adopted to provide a good ride and to increase the life of the vehicle by reducing the wracking stresses and shock loads imposed on it.

A leading-link suspension has been adopted at the front, while at the rear, trailing links are employed in conjunction with swing axles pivoted on the differential casing. With this arrangement, the rubber bushed pivots of the leading and trailing links are mounted on the cross members that support the seats, so that all the main load-carrying structure is within the wheelbase. This is sound in principle, because it enables the front and rear ends to be as light as possible. Another advantage of the leading and trailing link arrangement is that brake torque reaction tends to oppose any tendency for the nose of the car to dip when the brakes are applied. From the point of view of structural design, the absence of doors in the side of the vehicle is a great help, because the side panels below the waist form deep beams and make unnecessary the incorporation of heavy longitudinal frame members. Above the waist on each side there are two windows, each pair overlapping slightly at the centre. They are slid horizontally to open and close them.

A rack and pinion steering layout has been adopted, but the rack is connected to the front end of a lever which is pivoted between its ends and longitudinally disposed under the forward portion of the floor. The rear end of this lever is connected to a two-piece track rod. Conventional hydraulic brakes are employed. However, special measures have been adopted to ensure that they are adequately cooled. Air enters through a hole in the centre of the nave plate, and radial vanes blow it out round the periphery of the drum. All four drums are 160 mm diameter and the shoes are 40 mm wide.

The car is powered by a single-cylinder, air-cooled two-stroke engine of 248 cm³ swept volume. Its bore and stroke are 67 mm and 70 mm respectively, and a compression ratio of 7·1:1 has been adopted. This engine has an output of 14 b.h.p. at 5,200 r.p.m., and its maximum torque is 2·2 m-kg (approximately 15·9 lb-ft) at 3,500 r.p.m. Lubrication is effected on the petroil principle, the ratio of oil to petrol being 1:25.

A pneumatically-actuated diaphragm type fuel pump is employed and a Bing or Solex carburettor, with a 26 mm diameter choke, is fitted. Included in the installation is a Micronic air filter. A 12-volt 100 watt starter-dynamo unit is carried in the flywheel. Four rubber mountings on long bearers carry the whole of the engine installation. The capacity of the petrol tank is 22 litres.

The clutch and gearbox are housed in unit with the engine. A Duplex roller chain is used to transmit the drive to the clutch, which is a multi-plate oil-bath type unit. One reverse and four forward speeds are obtainable with the Bella-Roller gearbox. In reverse the gear ratio is 3·9:1, while the forward ratios are: first 4·16:1, second 2·1:1, third 1·33:1 and top 1:1. These ratios are multipled further by a reduction of 2·5:1 between the engine and gearbox and another of 2·5:1 in the final drive. A conventional propeller shaft transmits the drive to the differential unit. The tyre size is 4.40—12.

This vehicle is very compact. Its overall dimensions are: length 2,860 mm (9 ft 5 in), width 1,400 mm (4 ft 7 in), and height 1,380 mm (4 ft 6¼ in). A track of 1,150 mm (3 ft 9¼ in) has been adopted at the front and 1,180 mm (3 ft. 10¼ in) at the rear. The dimensions in English units are, of course, only accurate to about the nearest ¼ in. The wheelbase is 1,825 mm (6 ft) and the ground clearance, with four people in the vehicle, is 135 mm (5¼ in). A tare weight of about 400 kg (880 lb) is quoted, and the permissible load is also about 400 kg. It is claimed that the maximum speed of the vehicle is about 85 k.p.h., which is 53 m.p.h. The car is manufactured by Zündapp-Werke G.m.b.H., Nürnberg-Munchen, Dieselstrasse 10.

Fulda-Mobil

Among the four-wheelers with paired rear wheels is the Fulda-Mobil. This vehicle is a two-seater, but behind the bench type seat there are two folding seats, facing inwards, for small children. The squab of the bench type seat can be removed and laid flat behind the cushion to form a bed, which inevitably in such a small vehicle is not large.

A Fichtel and Sachs 200 cm³, single-cylinder air-cooled engine powers the vehicle. It is a two-stroke unit with a compression ratio of 6:1; it develops 10 b.h.p. at 5,250 r.p.m. The unit is equipped with a Bing horizontal carburettor, and the feed from the petrol tank is by gravity. A Dynastart electric starter and dynamo is employed, and a blower is incorporated for the air-cooling. This engine is installed at the rear of the vehicle. The drive is transmitted by a multi-disc oil bath clutch to a gearbox giving four forward speeds and one reverse. Final drive is effected by a chain, totally enclosed in an oil bath, and the ratio is 14:48.

Rack and pinion steering gear is employed. It is unconventional in that the rack and pinion unit is connected to one end of a pivoted lever, the other end of which carries the ball joints of a divided track rod system. This arrangement has been adopted because the front seat is immediately behind the front wheel arches so a more conventional steering gear layout could not be used without having the column almost vertical.

The front suspension is of the divided axle type. A transverse leaf spring is mounted above the axle pivots, and each end projects into a slider-block fitting, welded on the tubular axle below it. C-shaped swivel pin knuckles are welded to the outer ends of the axle. At the rear, a twin-wheel assembly on a trailing arm is employed in conjunction with a helical spring. All the tyres are 4.00—8.

Another unconventional feature of the vehicle is its pedal arrangement. All the pedals are mounted on the tubular cross member above the floor. They are horizontal and pivot about vertical axes. The pivot for the clutch pedal is on the left, that for the brake pedal is on the right and the throttle pedal, which is pivoted still further to the right, is curved to clear the brake pedal. An advantage of this arrangement is that it does not occupy much space under the floor; also, the control is less complex than it would be if pendant type pedals were employed.

The overall dimensions of the vehicle are: length 11 ft 1 in, width 4 ft 10 in and height 4 ft 4½ in, and the ground clearance is 7¾ in. At the front, the track is 3 ft 11¼ in. The wheelbase is 6 ft 0½ in. A turning circle of 21 ft 4 in has been obtained. The vehicle weighs about 780 lb.

Heinkel

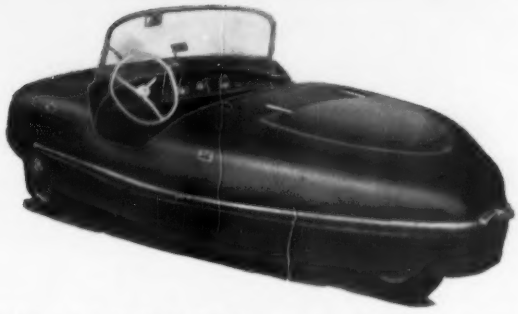
The Heinkel vehicle is similar to the Isetta in that it carries two abreast on a bench type seat and has a door in the front end. However, the steering column is attached by a strut to the door pillar and not to the door as in the Isetta. The gear lever operates in a gate bolted on to the left hand front wheel arch. All the pedals are pivoted on a cross member that form the door sill. The spare wheel is carried under the seat and therefore occupies space that otherwise would be wasted.

There is space for luggage behind the front seats. The distance between the seat squab and the forward edge of the engine compartment is 9 in. The shelf formed by the top of the engine compartment is 22 in from front to rear. At the front it is 40 in wide. A box for small articles is mounted above the front right-hand wheel arch, and a pocket is fitted on each side panel behind the wheel arches. The width of the seat at the waist is 43 in.

Most of these very small vehicles with large transparent panels all round above the waist tend to become very hot in sunny weather. However, to prevent this, the Heinkel has a cabriolet type roof. It is unfortunate that the triangular window at each front quarter is not a few inches higher, since a blind spot in the driver's range of vision is formed by the metal panel above its apex.

Rack and pinion steering is employed and the tyres are 4.40—10. The front suspension unit on each side is of bell crank form with the wheel on one arm and a coil spring

The Heinkel has a door in the front end. In this respect it is similar to the Isetta, but the steering column is attached by a strut to the door pillar



The Belcar is a plastics-bodied three-wheeler available in a number of different forms. The two illustrations here show drop-head coupés, one with and the other without doors

acting on the other. This spring, together with the telescopic hydraulic shock absorber, is totally enclosed in a telescopic cylindrical container. At the rear, the single wheel is on a trailing arm pivoted on a bracket on the rear of the engine crankcase. This arm also forms the case for the chain drive.

A good detail feature of the engine installation is the air-intake arrangement. The carburettor air-intake has a rubber bellows mounted round it. At the rear, the end of this bellows unit is open and bears against a box welded to the lid of the engine compartment. There are louvres in the lid and a hole in the wall of the box against which the bellows bear, so that the air can pass through from the extreme rear end of the vehicle. Thus, the air going into the engine is relatively clean, whereas if it were taken directly from the engine compartment, it would be contaminated by dust and mud thrown up by the rear wheel.

The engine is a single-cylinder four-stroke, air-cooled unit of the overhead valve layout, which develops 9·5 b.h.p. at 5,700 r.p.m. Its bore and stroke are 60 mm × 61·5 mm and its swept volume is 174 cm³. A Pallas 20/12P carburettor is fitted. The overall ratios of the four-speed gearbox are as follows: 23·04:1, 12·07:1, 8·08:1, 5·83:1, and reverse 18·10:1.

The overall dimensions of the vehicle are: length 8 ft 7¼ in, width 4 ft 6½ in, and height 4 ft 2 in. A wheelbase of 5 ft 9¼ in has been adopted and the track at the front is 4 ft 0½ in, while the ground clearance is 4¾ in. The dry weight of the vehicle is 535 lb and it is designed for a load of 510 lb.

Belcar

The Belcar is a plastics-bodied three-wheeler. It is powered by a Viktoria Swing, single-cylinder two-stroke engine. This engine has a bore and stroke of 65 mm and 60 mm, giving a swept volume of 250 cm³. It develops 11·3 b.h.p. at 5,300 r.p.m. Lubrication is effected on the petroil principle, and the carburettor is fed by gravity from the tank. The unit is air-cooled by forced draught. A multiple-disc oil bath type clutch transmits the drive to the four-speed gearbox.

This vehicle is fairly long, its overall dimensions being: length 11 ft 6 in, width 4ft 10 in and height 3 ft 11¼ in. A ground clearance of 7 in has been adopted. The wheelbase is 7 ft and the track is 3 ft 9¾ in. With a hard top, also of glass reinforced plastics, the vehicle weighs 615 lb. It carries 2-3 people abreast on a bench type seat. The vehicle is also available with a drop-head.

INSTITUTION OF MECHANICAL ENGINEERS

Forthcoming Meetings of the Automobile Division

DECEMBER

London

Tuesday, 11th December, 6.0 p.m., at 1 Birdcage Walk, Westminster, S.W.1. General Meeting. Paper: "Rubber Springs for Vehicle Suspension," by A. E. Moulton and P. W. Turner.

Birmingham

Tuesday, 11th December, 6.30 p.m., in the Queen's Hotel, Birmingham. Two papers on engine detail components—"Thermostats," by S. H. Blazey (Member) and "Recent Developments and Modern Techniques in the Use of Gaskets," by M. G. Herrington.

Derby

Monday, 17th December, 7.30 p.m., in the Midland Hotel, Derby. Paper: "A Review of Hydrokinetic Fluid Drives and their Possibilities for the British Motor Industry," by J. G. Giles (Associate Member).

North-Eastern

Tuesday, 4th December, 6.15 p.m., in the Cleveland Institute, Middlesbrough. Paper: "Front Suspension and Tyre Wear," by V. E. Gough, B.Sc. (Eng.), (Associate Member) and G. R. Shearer (Associate Member). This meeting is to be held with the North-Eastern Branch of the Institution.

Scottish

Monday, 17th December, 7.30 p.m., in the Institute of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow, C.2. Paper: "B.R.M. Car," by A. F. Rivers Fletcher.

JANUARY

London

Tuesday, 8th January, 6 p.m. General Meeting in conjunction with the Hydraulics Group. Paper: "A Review of Hydrokinetic Fluid Drives and their Possibilities for the British Motor Industry," by J. G. Giles (Associate Member).

Birmingham

Date and Paper to be announced later.

Coventry

Tuesday, 1st January, 7.15 p.m., in the Grosvenor Room, Leofric Hotel, Coventry. Paper: "Rubber Springs for Vehicle Suspension," by A. E. Moulton and P. W. Turner.

HIGH-PRODUCTION MACHINES

Interesting Examples of Specialized Equipment for Automobile Manufacture

If warranted by output requirements that will ensure continuous operation, or at least a high percentage rate of utilization, special purpose machines can usually offer substantial economies in production. For more modest requirements, discontinuous operation, or batch production, single-operation machines are more attractive, as their capital cost can be spread over a range of generically similar work items, over a longer useful life, or both. Such single-purpose machines may be specially adapted and equipped standard machines that can, if necessary, be re-adapted and re-equipped for other work, or special machines that are capable of handling a range of basically similar work. The three machines illustrated are representative of the three different types. All have been recently introduced and all are at present being operated in American or Continental automobile factories.

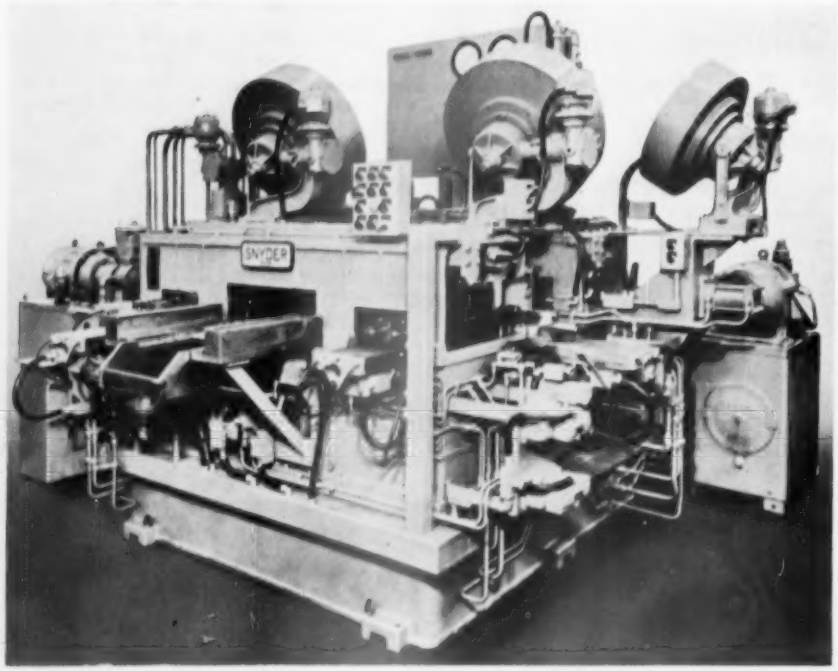
Snyder automatic assembly machine

This special-purpose machine is fully automated and is intended for installation in a transfer line. A seven-station machine with a walking-beam transfer, it closes and pressure tests the coolant jackets of right-hand and left-hand cylinder heads of a V-type engine. In an automatic sequence it applies sealing compound to three core holes, feeds and presses in three welch plugs, tests the jacket for tightness under air pressure, and discharges the finished component on to the line conveyor. A cylinder head failing to hold the test pressure is automatically withdrawn from the line for rectification.

An interesting feature of the machine is that it handles alternately right-hand and left-hand heads, identical as regards the castings except for core holes at opposite ends. Welch plugs are delivered to the work from individual hopper feeds that deposit one plug at a time in front of the hydraulically-operated plungers that press them into the casting. Maximum-stroke switches on each of these plungers control the machine cycle, so that transfer is stopped if any plug is not pressed in to correct depth.

The operational sequence is as follows. Cylinder heads are loaded into the machine at the first station and are then transferred from station to station by a hydraulically-operated, walking-beam type conveyor. At the second station laterally disposed, hydraulically-operated, latching levers move one head to one side of the machine and the following head to the other side. There the sealing compound is applied to the three core holes in each head; two on the side and one at the appropriate end of the casting. The heads are then returned to the conveyor and are passed through the third station, which is idle.

At the fourth, the heads are again transferred to opposite sides of the machine, where welch plugs are delivered into position and are then pressed in the casting. After return to the conveyor, the heads are then passed to the fifth station and are air-tested for leaks. Any assembly failing to sustain the standard test pressure is rejected and, at the sixth station, is removed from the line by hydraulically-operated overhead transfer bars. When rectified, such heads can be returned to the line at this point by the same overhead transfer



The Snyder automatic assembly machine applies sealing compound, presses in three welch plugs, and tests by air pressure alternate right-hand and left-hand cylinder heads for a V-type engine

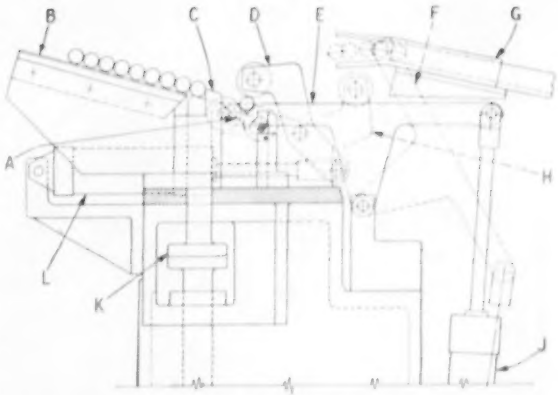
mechanism. At the last station the finished and tested heads are unloaded on to the line conveyor.

Built by the Snyder Tool and Engineering Co., East Lafayette, Detroit 7, Michigan, U.S.A., the machine has a fabricated steel base, is operated by two independent hydraulic power units, and is equipped with a centralized lubrication system. The floor space occupied is approximately 14 ft × 14 ft. Operating at 80 per cent efficiency, the output is 130 cylinder heads—65 pairs of right- and left-hand components—per hour.

Seneca Falls model LN automatic lathe

An excellent example of a standard machine tool furnished and equipped with standardized units to convert it into a specialized high-production machine is provided by this Seneca Falls lathe. Its evolution effected substantial savings in initial cost and also in delivery time, as compared with those for a specially designed and built machine. The requirement specification called for a machine to remove welding flash from a flash-butt welded worm shaft and to burnish the junction on a high-production basis. Essentially the machine comprises a pedestal base, a combined headstock and feed works unit, a headstock turning tool slide and a " packaged " automatic loader and ejector mechanism. All the main component parts are standardized items.

The welded parts are delivered directly from the welding machine to the lathe by conveyor whilst still red hot. From the conveyor the parts are deposited in the loading chute and flow by gravity to the fixed stop which determines the loading position. As the machining of a part is completed the spindle stops, the hinged steady-rest roll carrier is retracted clear of the work, the collet chuck opens and the finished piece is ejected from the collet by a spring-loaded rod. The shaft then rests on the unloader arms, which immediately swing it into the discharge chute and then return to the receiving position. An elevator assembly then raises another work piece over the loading chute fixed stop and deposits it into the loading cradle which remains in the raised position until the work is inserted into the collet chuck by a pneumatically-

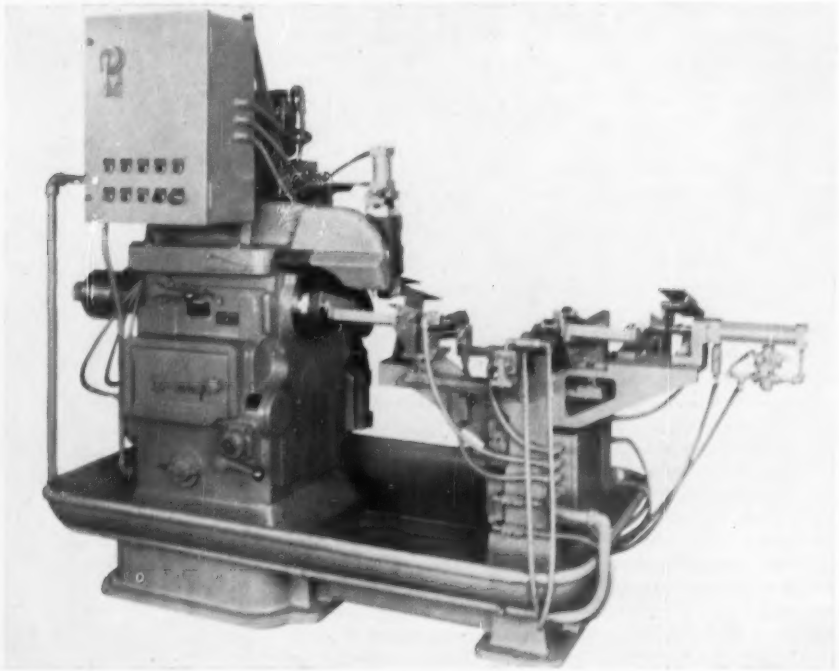


A—loading cradle, B—loading chute, C—fixed stop, D—hinged roll carrier, E—unloader arms, receiving position, F—unloader arms, discharge position, G—discharge chuet, H—roll carrier, relieved position, J—unloader operating cylinder, K—elevator assembly, L—roll carrier operating cylinder

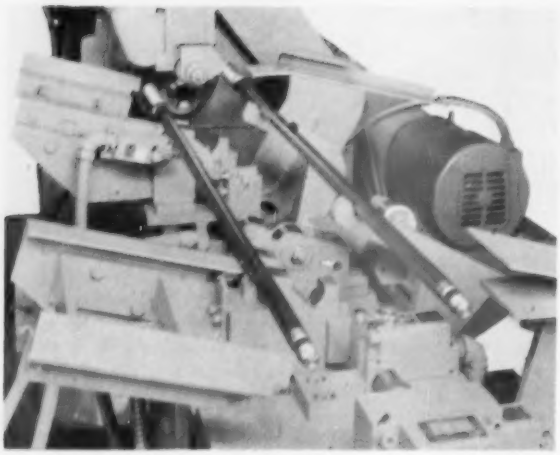
Automatic work-handling equipment

operated plunger. The collet chuck closes immediately, the elevator assembly retracts and the hinged steady-rest roll carrier automatically returns and closes on the work.

On the automatic engagement of the headstock spindle clutch, the tools on the slide are advanced to the cutting position, the flash is removed and the surface is burnished. The tools are then retracted and a new cycle is commenced. The smaller diagram of the tooling layout, shows the collet chuck mechanism, and the location of the insert-type carbide tool for removing the weld flash, and also the burnishing roll. The entire loading, machining and unloading operations are arranged on a fully-automatic cycle, but push-button controls are installed for the setting or the manual operation of each movement. The loading cycle cannot inadvertently become out of phase with the machine since automatic sequence is controlled by a system in which each movement is initiated only on the completion of the preceding movement. A



Seneca Falls Model LN automatic lathe adapted as a single operation machine for removing flash from a welded worm shaft assembly



A finished worm shaft being ejected and a rough workpiece about to enter the loading cradle

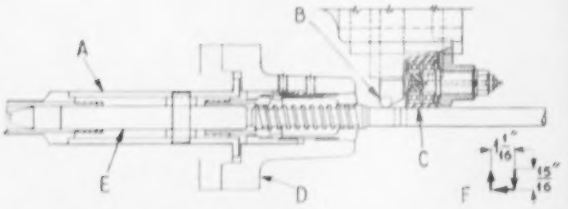
production rate of 275 pieces per hour is obtained without difficulty with this equipment.

The manufacturer is the Seneca Falls Machine Co., Seneca Falls, N.Y., U.S.A.

Hegenscheidt roller burnishing machine

This new machine enables the roller burnishing of stress-bearing components, to impart improved physical characteristics and better fatigue resistance, to be performed on a production basis. It is relatively simple to adjust and versatile in operation and is thus suitable for either continuous operation or for batch production.

The machine is of fabricated steel construction with the work spindle and its drive gear arranged in the base of the main column. Supported in anti-friction bearings, the spindle is both axially and radially adjustable and the drive is by vee-belts from an adjustably-mounted motor. Rapid chucking, with either hydraulic or pneumatic operation, is provided on the hollow spindle which has a special socket accommodating a range of chucking fixtures, collets, expanding mandrels and the like. Foot control at the front of the



A—collet chuck draw bar, pneumatically operated, B—insert-type carbide tool, C—burnishing roll, D—work-driver assembly, E—spring-loaded ejector rod, F—work travel diagram

Tooling layout on Seneca Falls machine

column base is arranged for the chucking operation. Work can, if necessary, be mounted between centres. In that case the hollow barrel of the tailstock together with its centre can be operated by the foot control. Alternatively, the chuck and the tailstock centre can be controlled by a common switch. All switches and control elements are mounted in a drawer-type frame housed in the machine column and readily withdrawable for checking or re-setting.

The actual roller burnishing tool is fitted to a slide which traverses on two hardened and ground guideways on the upper front of the column. Bearing surfaces on the slide are bronze plated to minimize wear in service. Burnishing rollers are mounted in eccentric bushings to enable their setting to be adjusted to a precise level. The burnishing head can be set to a specified work diameter and the rollers can be adjusted to an oblique position to ensure a good burnished finish on the work. Work up to 60 mm diameter and 300 mm long can be accommodated between centres. A typical rate of feed is 0·045 mm per revolution.

An oil-hydraulic cushioning system is provided in the slide feed for fillet radius burnishing operations. Burnishing can thus be performed at a consistently uniform axial contact pressure. Control of the contact pressure can be effected either by a pneumatic-hydraulic system with a pressure intensifier or directly by hydraulic means. The actual contact pressure applied to the work can be read from a pressure gauge located at eye level. For certain operations, the deep rolling of fillets or the burnishing of seatings for anti-friction bearings for example, the feed mechanism may be put out of action and a special time-limit switch used to afford pre-selection of a specified operating period.

Switches for the several functions are arranged on the right and left of the work table. Operation can be on a fully automatic machining cycle or by single operations manually controlled as may be desired. The machine is equipped with a one-shot lubrication system actuated by a single lever.

In Britain the Snyder and the Seneca Falls machines are handled by Gaston E. Marbaix, Ltd., Devonshire House, Vicarage Crescent, London, S.W.11, and the Hegenscheidt machine by Vaughan Associates, Ltd., 4 Queen Street, Curzon Street, London, W.1.

Hegenscheidt semi-automatic, heavy duty, roller burnishing machine

Fuels for High Performance Engines

Quality Requirements for Modern Spark-Ignition Power Units

J. G. Withers, B.Sc., M.I.Mech.E., and H. J. Eatwell, M.B.E., A.M.I.Mech.E.

THE recent introduction of 100 octane number petrol for sale at service stations to the private motorist is a milestone in the development of the petroleum and automotive industries in this country and, indeed, in the world. For the British petroleum industry has put at the disposal of our automotive industry 100 octane number fuels well in advance of their availability in many other parts of the world. The United States and Italy are the only other countries where fuels of this high quality have been available on a limited scale since early in 1956.

Over the past forty years, the development of the automotive and petroleum industries has been closely related. Automotive engine designers, in their persistent efforts to produce more efficient power units, have steadily raised compression ratios, while at the same time the oil industry has undertaken the complementary development of fuels of higher and higher anti-knock quality. The progress made since the war is shown in Fig. 1, and indicates the value of the co-operation of these two industries. In the United States developments in fuel quality have been at a steadier rate than in this country, because there, in the immediate post-War years, quality was not so affected by economic restrictions as it was in Great Britain. Now the petroleum industry in Britain has not only provided the fuels needed to enable engines of higher efficiency to be developed, but has made these fuels available on a nation-wide basis in readiness for the introduction by the automobile industry of engines of advanced design.

Development of these new 100 octane number fuels presents not only a problem of increasing anti-knock quality, but also of providing for all other aspects of the fuel quality requirements of the modern high performance engine. The object of this article is to present this aspect of overall balanced high quality, and thus to keep the automobile industry and users informed of what quality is available to them in these new motor fuels.

The ability to produce fuels of this high quality depends upon refinery processes such as catalytic cracking, catalytic reforming and catalytic polymerization. These processes produce motor fuels that are rich in olefinic and aromatic hydrocarbons. The extent to which the components, or fractions of the components, from these processes are used to produce a finished fuel depends upon the final performance required and the refining economics. To ensure that these high quality motor spirits have the performance characteristics suitable for the engines in which they will be used, it is necessary for accurate forecasts to be made of the fuel requirements of future engines. This presents some difficulty, as there are very few automobile engines that can use to the best advantage the qualities of 100 octane number fuel. It is also important that the automotive engine should be designed to take full advantage of the new fuels.

Gasoline additives

The use of additives in motor spirit is a practice almost as old as the industry. There are many reasons for their use and the types and quantities used vary from one company

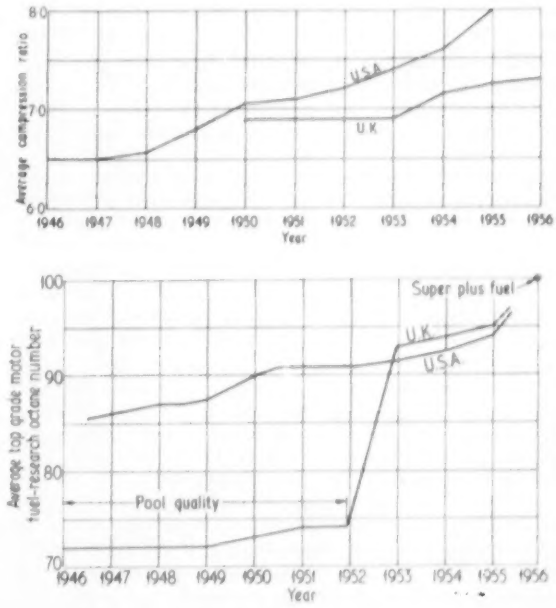


Fig. 1. Compression ratio increase and the progress that has been made in anti-knock quality from 1946 to 1956

to another, depending upon refinery operations, cost considerations, and the quality of the final product supplied to the user. For example, lead tetraethyl, the anti-knock additive used in all gasolines, need not be used at all to produce 100 octane number fuel if cost to the consumer were unimportant, for it is possible by certain refining processes to reach this level of quality without the addition of lead. However, the new 100 octane number petrol developed by the British Petroleum Company has been produced with a lead tetraethyl content in the same range as that of motor spirits currently being marketed in Great Britain.

Other additives such as oxidation inhibitors, corrosion inhibitors, combustion control compounds, and anti-icing additives can all play a part; but the important factor is the final performance of the fuel. Therefore, in this article, the authors deal only with the ultimate results of the different quality aspects and not the methods by which they are reached.

Anti-knock quality

It is well known that increase in the compression ratio of an engine increases its efficiency, thereby reducing the fuel consumption and increasing the power output. However, the theoretically possible improvements are to a small extent offset by the need to make the engine stronger to withstand the high pressures resulting from higher compression ratio;

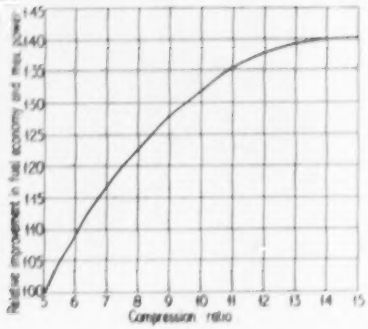


Fig. 2. Effect of compression ratio on engine performance

this increases slightly the friction losses. Fig. 2 gives a relationship between compression ratio and performance, based on the mechanical losses associated with current engine design experience; there is seen to be no improvement beyond a compression ratio of 15:1. The improvement in power output and fuel economy is 40 per cent for the extreme difference in compression ratio of from 5 to 15:1 in Fig. 2, whilst the improvement for a change from a 7½:1 to a 10:1 compression ratio is 10 per cent.

Unfortunately, increase in compression ratio leads to a greater tendency to knock, so the maximum usable compression ratio is limited by the fuel quality available. Knock or detonation is believed to be the autoignition of part of the fuel-air mixture ahead of the combustion flame in the cylinder; it causes loss of efficiency and, when heavy, damages the engine. The incidence of knock in a car engine should cause the driver to change to a lower gear. Thus, fuel consumption is adversely affected, or performance is restricted by limiting the usable throttle opening.

A single cylinder, variable compression ratio engine, which is internationally standardized and known as the CFR Engine, is used to determine the anti-knock quality of motor fuel. The fuel is compared with blends of two reference fuels—normal heptane, which has a low anti-knock quality, and iso-octane, of high anti-knock quality. Anti-knock quality is expressed as octane number and is the percentage of iso-octane, in blend with normal heptane, that gives the same intensity of knock in the test engine as does the fuel under test. Thus if a petrol is said to have an octane number of 100, it means that under the conditions of test used, it has the same anti-knock performance as iso-octane.

The octane number obtained by tests in the CFR engine depends upon the test conditions used as well as upon the anti-knock quality of the fuel. Two methods of test are applicable to motor fuels, the Motor Method and the Research Method.[2] It is recognized throughout the petroleum and automotive industries that of the two, the Research Method is more suitable for the forecast of the anti-knock quality of fuels in modern high compression ratio car engines.

What can be gained from the use of 100 octane number fuels? Broadly the answer to this question is that engines designed to make good use of 100 octane number will show important improvements in power output and fuel economy.

Fig. 3 shows how the minimum fuel anti-knock quality to give knock-free operation, or the *octane requirement*, of vehicles on the road, varies with compression ratio. The data given are based on stabilized octane requirements, that is, they are determined when the car has run a sufficient number of miles beyond which build-up of combustion chamber deposits and other causes cease to increase the octane requirement. Stabilization usually occurs after about 5,000 miles. The full line drawn in Fig. 3 is based on work carried out on the General Motors Research engine, but the shape of the curve is probably typical of other engines; the crosses are the results of tests on individual cars, and the scatter indicates the wide differences that are obtained between different designs.

From Fig. 3, it can be seen that fuel of 100 octane number is satisfactory for the average engine of 10:1 compression ratio. At present, few cars have compression ratios exceeding 8:1 and the new fuel will only show up to full advantage in engines of advanced design. However, it is evident from the illustration, that there can be a considerable spread of octane requirements for any one compression ratio, and readily detectable improvements in engine smoothness have been found at compression ratios appreciably below the level for optimum performance. Correlation of the data in Figs. 2 and 3 shows that fuel economy and power output are improved by approximately 1½ per cent for each increase of one octane number in fuel quality, provided, of course, that use is made of the octane number increase to raise the compression ratio.

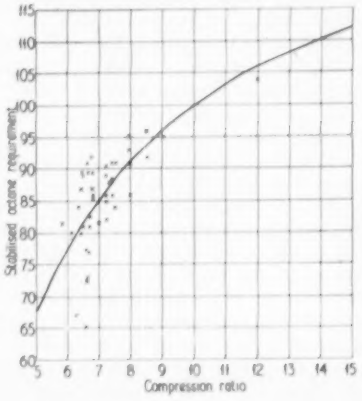


Fig. 3. Effect of compression ratio on octane requirement

Another way of increasing the power output of an engine is by improving its breathing capacity, since the more air the engine draws in, the more fuel it can burn and the more power it will give. Improved breathing can be obtained by reducing to a minimum the restriction to the flow of the gases entering and leaving the cylinder; by avoiding unnecessary heating of the ingoing mixture; and by making use of pressure pulsations in the inlet or exhaust systems to induce a better filling and scavenging of the combustion chamber.

Other things being equal, improved breathing, like increase in compression ratio, raises the octane requirement of the engine. It is equivalent to a wider opening of the throttle. For each 3 per cent increase in power gained by improving breathing or supercharging, the fuel must be increased in octane number by one unit. However, unlike increases in compression ratio, deeper breathing does not lead to a corresponding improvement in economy, but there is a bigger return (3 per cent instead of 1½ per cent) in power output improvement if a unit gain in octane number is utilized by improved breathing rather than increase in compression ratio. It is to be expected, therefore, that designers will always strive for the best breathing characteristics possible in order to obtain the best power output from an engine of a particular size.

If octane numbers are wasted by faulty design, then the compression ratio and breathing capacity of the engine cannot be taken to their maxima. The most important factor is proper cooling of the combustion space; and the important parts are the exhaust valve, spark plug and piston. Proper cooling of the first two can be obtained by adequate

water passages, and a sufficient and directed flow of coolant; and of the last by careful attention to design and by oil cooling. High surface temperatures, apart from inducing ordinary knock or detonation, increase the liability to pre-ignition due to the origination of combustion at the hot surfaces before the spark passes. Engines should be designed so that there is little tendency for combustion chamber deposits to form, particularly in the region remote from the sparking plug, as many octane numbers can be lost by build up of deposits in this region. The major effect of the deposits is not that of increasing compression ratio, but that of providing a heat insulating barrier so that the surface temperatures are hotter. This effect can be mitigated by design of the combustion chamber, valves and inlet manifold to control gas movement in the combustion space.

It is useful to design an engine so that the power output is relatively insensitive to spark advance; a compromise distributor-characteristic can then be adopted which gives minimum octane requirement without appreciable loss in power. Since the cylinder that knocks first determines the octane requirement, the inlet system should be designed not only so that all cylinders receive the same mixture strength, but also so that the different components of the petrol are distributed equally, that is, so that all cylinders receive the same octane number. Slight enrichment of the mixture at full throttle, particularly at low speeds, to suppress knock, is permissible because operating time at full throttle is a small enough percentage of the total running time to have only a minor effect on fuel consumption.

Octane requirements of different cars of the same model can vary in extreme cases by as much as 20 numbers. This is caused by a large number of factors influenced by manufacturing tolerances, and there is much to be gained by reducing these variations. In addition, the owner can waste octane numbers and lose performance in many ways, of which the following are some of the more important:

1. Over-advancing the ignition setting beyond the value giving the best performance.
2. Failure to renew the distributor when necessary. A worn distributor can give uneven timing to the different cylinders, and the centrifugal device which advances the timing with speed may not function accurately when the springs become weak and the pivots worn.
3. Allowing the cylinder jackets to become furred, which causes higher internal surface temperatures. Certain additives in the water or anti-freeze are helpful, and an occasional descaling treatment may be desirable.
4. Continuing to run the car when the oil consumption has become excessive. This increases combustion chamber deposits, which may lead to high surface temperatures; lubricating oil may cause knock if burnt in sufficient quantity.
5. Using an unsuitable fuel or lubricating oil, which aggravate internal deposit formation and adversely affect heat transfer rates.

Motor fuel of 100 octane number is necessary for engines of advanced design which give significant gains in power and economy. It is useful primarily for engines having a compression ratio of more than 8:1, but may be required in other engines because of bad design or condition, or to give an improvement in general smoothness of running.

Volatility

Motor spirit is a mixture of hundreds of different individual compounds called hydrocarbons, each of which has a different boiling point. There are so many such compounds in a fuel that when it is distilled, the volume collected varies more or less continuously with the temperature of distillation. The volatility of a petrol is measured by the ASTM Distillation Test,[2] and is expressed by the percentage distilled at various temperatures. Fuel volatility affects many engine performance characteristics including the following:

Ease of starting
Warm-up time
Fully warmed-up performance, or *throttle response*
Tendency to cause carburettor icing
Tendency to cause crankcase oil dilution
Tendency to cause vapour lock and percolation.

Examination of each of these features in turn shows that some of the requirements are conflicting, and that a careful balance is necessary to obtain the best all-round results. The first five of the above listed requirements are primarily concerned with low temperature conditions. Many tests have been carried out by the authors' company in this country and Europe, culminating in a series of winter tests in Sweden, at temperatures as low as —37 deg C (—35 deg F), using nine specially prepared fuels and eleven cars manufactured in six different countries.

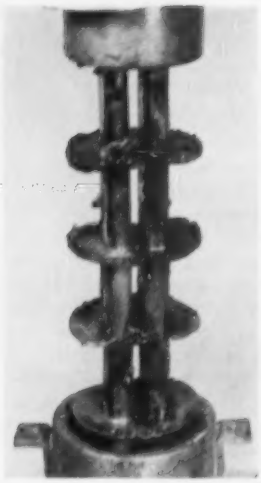
At low temperatures, the difficulty in providing an ignitable mixture for starting increases, so the fuel has to be more volatile. The components at the beginning of the distillation range, that is the first to boil, primarily affect starting. In fact, the temperature at which ten per cent of the fuel has distilled is the best guide to ease of starting.

In Great Britain, winter temperatures are seldom below —6·5 deg C (20 deg F); nevertheless, for satisfactory operation at this temperature, ten per cent of the fuel should boil below 60 deg C. Such a fuel gives easy starting at all temperatures above —6·5 deg C (20 deg F); also starting with it is not impossible at temperatures as low as —20·5 deg C (—5 deg F). In the summer, the temperature does not drop below 1·5 deg C (35 deg F) and the ten per cent distillation temperature of the fuel can then be as high as 70 deg C. It is desirable to reduce volatility in the summer months to avoid vapour lock.

Warm-up characteristics of a fuel can be measured by making full throttle accelerations from low speed during the warm-up period. It is assumed that the engine is warmed-up when its full performance can be substantially attained. Warming-up time increases as the atmospheric temperature drops, and is roughly doubled for each 20 deg C (36 deg F) fall in temperature; this effect is as much due to increased viscosity of the lubricating oil as to the condition of the mixture in the cylinders.

The best guide to the warm-up characteristics of fuels is given by the temperature at which 50 per cent distils. Good warm-up characteristics are given at all temperatures down to —18 deg C (0 deg F) by fuels which have at least 50 per cent boiling below 100 deg C. Such fuels also give good fully warmed-up performance, that is, quick response to sudden changes in throttle opening. Slightly less volatile fuels are satisfactory in the summer months.

Carburettor icing occurs with certain installations in which a large reduction in the temperature of the intake air and carburettor parts occurs owing to the latent heat of vaporization of the fuel. When cool air of high relative humidity is drawn through the carburettor, its temperature may be reduced below the freezing point of water, in which case some of the water vapour condenses in the carburettor and ice is formed. This ice may be deposited in various parts of the carburettor and restrict the flow of fuel; its presence is manifested by stalling during warm-up, or in extreme cases by complete, though temporary, stoppage of the vehicle when fully warmed-up. Such troubles occur when the temperature is in the range of —2 deg C to +13 deg C (28-55 deg F) and when the relative humidity is above 65 per cent. Absence of conducted heat to the affected parts of the carburettor, and over-ventilation of the under-bonnet space are the major design causes. A large reduction in fuel volatility prevents carburettor icing but, since icing is a winter



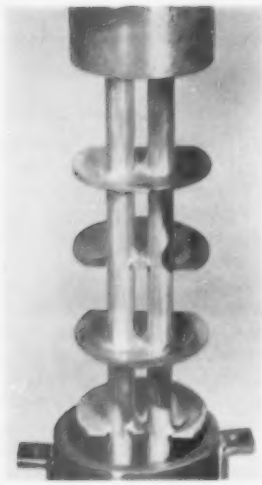


Fig. 4. Left: Manifold gum deposits from inadequately refined fuel

Fig. 5. Right: Manifold gum deposits obtained with a satisfactory fuel

problem, such a solution would conflict with ease of starting and quick warm-up. It is fortunate, however, that icing troubles can be completely cured by the incorporation in the fuel of certain special additives. Crankcase dilution does not occur with vehicles in good condition, provided the fuel distillation is completed by 210 deg C.

At high temperatures, vapour may be formed in the fuel pump or carburettor. This can cause either an interruption of the fuel supply, or *percolation*, that is, periodic syphoning of fuel into the choke tube. These troubles are most likely to occur if, after a period of hard driving, the car is allowed to idle or stand for a period. In these circumstances, the fuel system temperatures then *soak* to much higher values than those obtained when the vehicle is running normally on the road. The occasions when the trouble is most likely to occur are in traffic jams or when the driver attempts to start the vehicle after a stop of about a quarter of an hour. If the fuel pump is well clear of, or shielded from, the radiation from the exhaust pipe, vapour lock is unlikely to occur. Also the provision of high-level vents in the bonnet, to provide air circulation when the vehicle is stationary, is a good design feature. In fact, all measures that reduce fuel system temperatures, particularly when the vehicle is standing, are desirable. The provision of ample cooling air when the vehicle is in motion is a measure that must be applied with discretion; if carried to excess this could lead to carburettor icing troubles in winter. Installation of the fuel pump at the level of the base of the petrol tank is also beneficial, as it ensures that the pressure in the whole of the fuel system is above atmospheric. If it is mounted on the tank, or well away from the engine, the pump of course is kept cool.

Naturally the more volatile the fuel the greater is its tendency to give off vapour at a given temperature. Fuel systems are capable of handling a surprisingly large amount of vapour, and experience has shown that in the average car, difficulties are experienced only when the volume of vapour is 36 times the volume of fuel.[3] Thus, fuel vapour lock characteristics are measured by the temperature to which the fuel must be heated to give a vapour : liquid ratio of 36 : 1.

The British Petroleum Company have determined the characteristics of the fuel systems of many cars at high summer temperatures in Great Britain, Continental Europe, and in Algeria, under both level road and mountain-climbing conditions. These tests have covered atmospheric temperatures up to 50 deg C (122 deg F), although the maximum British summer temperature maintained for any reasonable period is 30 deg C (86 deg F), and this maximum only occurs inland in the South of England.

Fuel system temperature rises approximately one degree for each degree rise in shade temperature. In the best car tested, temperatures of parts of the fuel system critical to vapour lock rise to 25 deg C above atmospheric temperature, and in the worst car tested they rise to 50 deg C. The average rise is 33 deg C. Determined efforts should, of course, be made to reduce these temperatures.

It should be noted that the volatility criteria referred to above are values that are acceptable, but they are not necessarily the optimum values used in marketed fuels. The volatility of a high quality fuel must be very carefully balanced to meet the conflicting demands of starting and quick warm-up on the one hand, and freedom from vapour lock on the other; it must also be adjusted to suit the particular climatic conditions in the market concerned and to suit as wide a range of operating conditions as possible. The optimum volatility for user satisfaction can only be chosen as a result of extensive road tests.

Engine cleanliness and overhaul life

This aspect is one which users seldom associate with fuel quality, except in so far as it concerns the combustion chamber. Few users realize the great influence motor spirit quality can have on the formation of lacquer and sludge in engines, especially under adverse running conditions. These formations, of course, are also closely associated with the quality of lubricating oil used, since a high quality detergent oil can often mitigate the adverse conditions that might develop if a poor quality fuel were used.

In providing high octane number, it is important that other qualities are not sacrificed. Fuels must be stable so that after manufacture they can be stored for reasonable periods before the customer uses them. Unstable fuels lead first to gum deposition in pumps, carburettors and induction manifold assemblies, and subsequently to inlet valve sticking. Piston lacquer and ring sticking would eventually develop if an engine were consistently supplied with unstable fuel.

Although many laboratory tests are used to give day-to-day control of the stability of motor spirits and their effect on engine performance, experience shows that only engine tests can finally prove the efficiency of the processes used to meet the market requirements. The authors' Company uses a number of engine test techniques in this sphere.

One of these is a test in which a single cylinder engine of $2\frac{5}{8}$ in bore × $2\frac{3}{4}$ in stroke is used. This engine is run for 20 hours at 1,800 r.p.m., with a water outlet temperature of 100 deg C, an oil temperature of 60 deg C and a mixture temperature of 66 deg C. By means of this test, the tendency of a gasoline to form gum in the carburettor and induction manifold is evaluated.[4] Figs. 4 and 5 show the gum deposits formed on the blades of a special heater inserted in the manifold of this engine. In Fig. 4 is shown the condition after 20 hours of running with an inadequately refined fuel, and in Fig. 5 with a satisfactory fuel. The results of this test have been correlated with road tests, so that the quality required to prevent gum deposits and inlet valve sticking is known.

Conditions most likely to lead to lacquer and sludge deposits, as a result of the use of unstable fuels, are light and medium load operation at low temperature. Under these conditions, fuel dilution of the lubricating oil occurs; this dilution is due to unvaporized fuel, which, together with the products of partial combustion, pass the piston and ring assembly into the sump of the engine. With an unstable gasoline, the products of partial combustion contain high proportions of gum and lacquer, some of which are deposited

on the piston assembly during the passage of the products of partial combustion into the sump. The products that reach the sump are then circulated with the lubricating oil and tend to be deposited.

Two tests are used by the British Petroleum Company to measure the tendency to form fuel deposits. One is made with a six cylinder truck engine of $3\frac{1}{4}$ in bore, $3\frac{3}{4}$ in stroke, running at 2,500 r.p.m. and developing 45 b.h.p. For the duration of each test, 40 hours, the jacket temperature is regulated to 38 deg C, and the sump temperature to 74 deg C. The second test is made with a four cylinder engine of $3\frac{1}{8}$ in bore, and $4\frac{3}{8}$ in stroke, run at 65 deg C jacket temperature, and 50 deg C sump temperature, under start-stop conditions, with the load and speed varied to simulate door-to-door delivery duty.

With regard to the combustion chamber, the first feature that is commented on by most users is exhaust valve life. This is natural as, in many engines, until recent years the life of these components has been unsatisfactory. However, this aspect of engine development has received much attention, and modern units are giving much more satisfactory service. This is due not only to improved materials, but also to the gradual disappearance of the side valve engine and a realization of the importance of providing for adequate and uniform heat transfer at both the valve seats and guides. Exhaust port shape and guide position also play their part. The ultimate in exhaust valve design was referred to in a recent symposium;[5] in an aircraft engine the valve life is now known to be equal to that of the complete engine. This is also achieved in a few automobile engines, but at a cost. However, exhaust valve life in general is now much better than it was a few years ago.

Valve burning tests are made in engines prone to this trouble. Four cylinder side valve engines are used. They are run under cyclic heavy duty conditions. However, as the authors believe that the false impression may still persist in some users' minds that high octane number fuels are too *hot* for normal engines and will lead to valve burning, it is of importance to emphasize that the new 100 octane number fuels produced by the authors' Company contain no components likely to affect valve life adversely by comparison with fuels already marketed by them, and that the user can rest assured that there will be no deterioration in valve life as a result of their use.

The effect of combustion chamber deposits on engine performance is well known, and the question of octane requirement increase has been dealt with in a previous section. However, the effect of fuel quality on deposit formation and also on pre-ignition tendencies is one which must be kept under constant review by both the petroleum and automotive industries. To deal with this, engines with representative combustion chamber designs suitable for use with fuels of high quality are employed. They are run under normal operation conditions until deposit stability is reached. During the course of this work the octane requirements are measured and also observations for pre-ignition are made. In the engines currently available, pre-ignition does not occur with a satisfactorily formulated 100 octane number fuel. As engines that require even higher levels in anti-knock quality are developed, it is important that they are made available, at an early stage, to the petroleum industry.

General comment

The new 100 octane number motor fuels made available throughout Great Britain should enable the automobile industry of this country to build engines having compression ratios up to 10 : 1. These fuels not only provide high anti-knock performance but, in addition, have a balanced quality so that their volatility and stability are equal to or better than the gasolines already available, as also is the engine cleanliness experienced when they are used. In conclusion, the authors wish to thank the Chairman of the British Petroleum Co. Ltd. for permission to publish this article.

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TEFLON FABRIC DRY BEARING

IN recent years, a number of bearings for use without lubricant have been developed. So far, one of the most successful in this country has been the Glacier dry bearing, described in the December, 1954, issue of *Automobile Engineer*. The Nylacore bearing was later developed in the United States; this was mentioned in the February, 1955, issue of *Automobile Engineer*. One of the latest additions to the range of bearings of this type produced in America has been developed by the American Metal Products Co., of Detroit. Most of this company's efforts have so far been directed towards the application of the new bearing to suspension components, with a view to the elimination of lubrication points and reduction of friction.

The key to the success of this development is the use of Teflon fibre, woven into a fabric, as the anti-friction medium. Teflon, which is similar to the PTFE material used to impregnate the metal of the Glacier dry bearing, is made by E. I. Du Pont de Nemours and Co. Inc., of Delaware, U.S.A. In the new American bearing, the Teflon is double-woven with a backing of nylon or cotton, and is then laminated and preformed with cotton-reinforced phenolic resin. When the bearing is used in a ball-and-socket suspension joint, the metal components are coated with a special grease to prevent corrosion, and the laminate is preformed into a cup, which lines the socket. The joint is assembled and the preformed bearing is cured in place. This ensures that perfect spherical contact is made between the ball stud and the bearing. Finally, the joint is sealed. The manufacturers state that preliminary tests have indicated that these bearings will last the lifetime of the vehicle, without lubrication or other maintenance. In addition, they say that the cost of this type of joint is no greater than that of a comparable standard ball joint.

There are, of course, many other applications for this type of bearing. They include spherical end-fittings for control rods; self-aligning bearings; cylindrical components, such as bushes and hydraulic piston type valves; and flat or sliding components, including leaf spring end-pads. Apart from the fact that bearings made of this material function without lubrication, their friction is said to be lower, by more than 50 per cent, than that of standard lubricated suspension joints. Another advantage is that they do not squeak. The new bearings are expected to be used primarily in joints subject to intermittent motion, where overheating is not a serious problem, although Teflon will withstand temperatures of up to 500 deg F, which is high for plastics materials.

CAR WHEEL MANUFACTURE

High-Rate Production at the Works of Joseph Sankey and Sons Ltd.

WHEELS may be regarded as the fundamental basis of all surface transport. Their invention is lost in antiquity and they have slowly evolved throughout the entire span of recorded history. As roads were improved and horse-drawn carriages become more refined and more luxurious, the spoked wooden wheel shod with a metal rim was brought to a high stage of development. Always the wheelwright's was a highly specialized craft. It was necessarily so, since the functional requirements to avoid "lift," or eccentricity, and "run-out," or wobble, called for a precision in measurement and a meticulous care in building which, until relatively recent times, were in advance of contemporary technical standards.

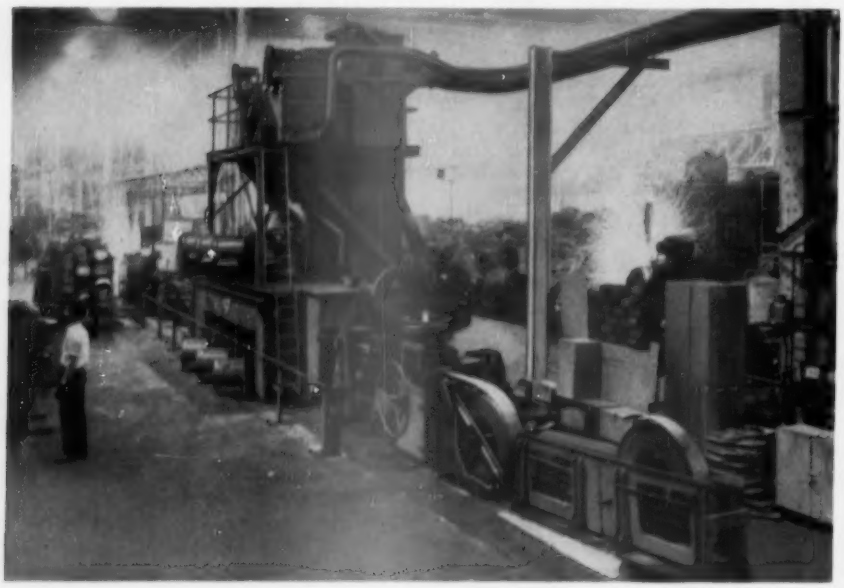
The earliest builders of motor cars had but a limited choice of wheels. After a few examples had been fitted with large diameter, narrow-rimmed, wire-spoked wheels of the type now termed rickshaw wheels, wooden-spoked artillery wheels were adopted. They were at first metal shod, later fitted with solid rubber tyres, and eventually with metal rims and pneumatic tyres.

The firm of Joseph Sankey, which had its modest beginning at Bilston, Staffordshire, in 1854, early in the twentieth century was engaged on steel presswork and fabrication. It had already set up a motor-car body-building department and was supplying pressed steel body panels for fitting on wooden framings to manufacturers in Britain, France and the United States of America. It was in that period, prior to World War I, that the firm produced the first all-steel, pressed wheel in the world. This was the patented, steel artillery wheel, which met with general approval and was supplied to car manufacturers in all parts of the world. It comprised two symmetrical, apertured pressings, the peripheral margins of which were rolled over the edges of a relatively light profiled rim. The two pressings were edge-welded together around the apertures, thus forming what were, in effect, tubular spokes.

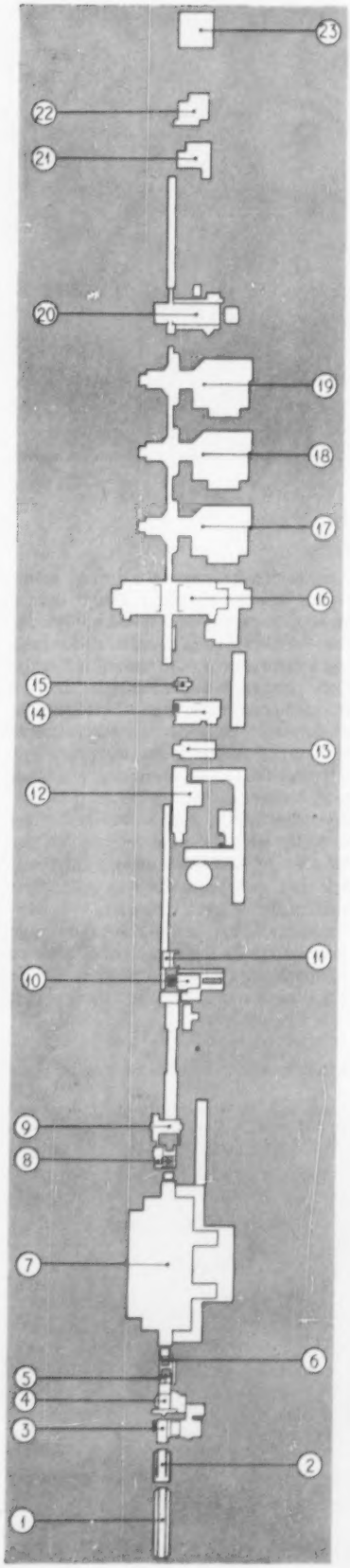
In order to meet the demands of the then rapidly growing car industry, a move was made in 1910 to Hadley, outside Wellington, Shropshire, to a larger works with room for expansion. In that year bodies, panels, chassis frames and wheels were supplied to many of the pioneering manufacturers, including Austin, Daimler, Humber, Morris, Lanchester, Rolls-Royce, Rover, Singer, Standard, Sunbeam, Vauxhall, and Wolseley. The early records of the Company are of considerable interest and evoke comparisons with present-day conditions. For example, the firm supplied the chassis frame for the Ford Motor Company's £100 car at a cost of 22s. 6d. each.

The Hadley works was continuously expanded and towards the end of World War II a production unit for 1,000,000 wheels per year was planned. This was to handle wheels for cars and commercial vehicles and also for agricultural tractors, for which a greatly increased demand was expected. By 1950 the annual output had been raised to more than 2,000,000 wheels and currently it is running at the rate of 12,000 wheels per day. In addition to wheels, the firm produces panels, pressings, and chassis frames for the motor industry and a wide range of presswork and fabrications for other industries. In the post-war period the plant has been expanded from 27 to 50 acres in area and the number of employees has risen from 2,500 to more than 4,000. The current output of the plant is approximately 750 tons of products per day.

Although the tension-spoked wire wheel was brought to a high stage of development for racing cars and enjoyed a certain measure of popularity for normal touring vehicles,



Commencement of the rim line, showing the coil rack, de-coiler, flattening rolls, cropper, welding station and pinch rolls preceding the Wheelabrator plant



Layout of car wheel rim line

1 Coil rack
2 De-coiling machine
3 Flattening rolls
4 Cropping machine
5 Welding station
6 Pinch rolls
7 Wheelabrator plant
8 Flattening rolls
9 Flying shear
10 Circling machine
11 Hydraulic lift
12 Flash-butt welder
13 Burr-shearing machine
14 Weld-rolling machine
15 Weld-trimming grinder
16 Preform press
17 1st forming rolls
18 2nd forming rolls
19 3rd forming rolls
20 Expander
21 Press (valve depression)
22 Punch (valve hole)
23 Inspection bench

the firm has consistently concentrated its efforts on the pressed steel wheel. It is held that while a case could be made for the wire-spoked component when wheels were of relatively large diameter and had relatively small hubs, it is not so suitable for the modern style of small-diameter wheel which has a large hub. The recent trend to fit wire wheels on certain production cars to convey a sporting appearance is regarded as a fashion whim which originated in the U.S.A. and which, in that country, is already declining. In like manner the firm had little interest in the welded-spoke wheel. The only compromise was the Magna Artillery wheel, which was of the disc type but apertured to simulate the appearance of spokes.

To keep abreast of changing requirements and increasing demands, the plant undergoes virtually continuous development. A section or a production line is comprehensively replanned, new tools are acquired or specially built, and new techniques are developed experimentally. To avoid holding up the flow of production, new items of equipment are introduced into a line, or existing machines are re-sited, individually or in convenient groups. In some instances newly-developed machines are temporarily sited alongside an existing production line and proved in operation before being introduced into the line.

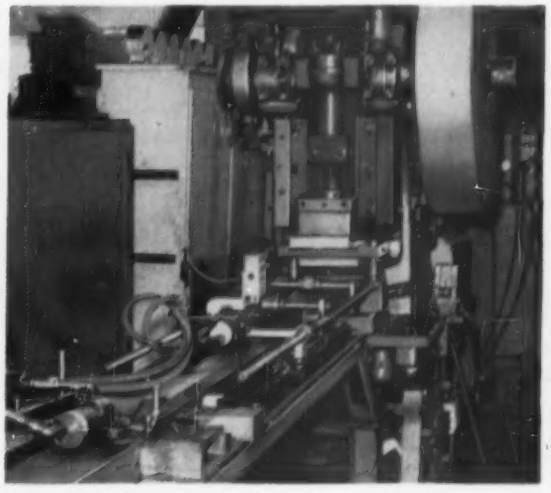
Recently the main production line for car wheel rims has been completely reorganized in this manner and the car wheel centre and the wheel assembly lines are currently being re-tooled and re-sequenced to match the new rim line.

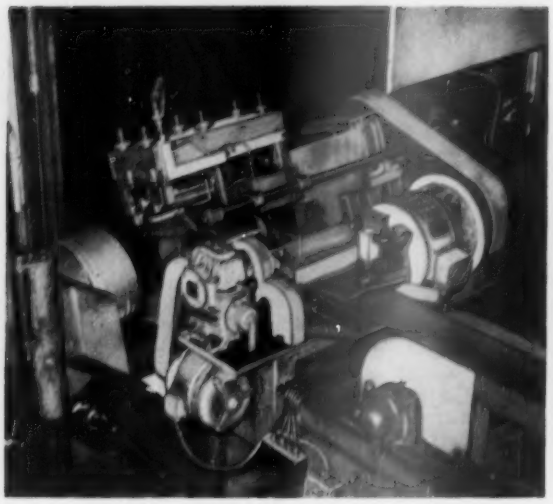
Wheel rim line

A low-carbon mild steel is used for car wheel rims and the material specification usually stipulates a composition with 0·08 to 0·13 per cent carbon and a combined sulphur and phosphorus content not exceeding 0·04 to 0·06 per cent. This material is rolled to specified widths and is received from the steelmaker in coils of a length sufficient for approximately 120 rims.

At the commencement of the rim line is an inclined rack holding three coils of steel ready for use. This is loaded from a supply of stock coils deposited on the shop floor alongside. From the rack a coil is released to deliver by gravity to the de-coiling machine, where it is set up and the free end is passed through flattening rolls. It is then cropped to remove any damaged material and trim the end square in preparation for joining to the tail end of the strip already on the line.

A flying shear cuts the moving strip material to precise rim lengths





Strip-circling machine, with feed rolls in the foreground

Circles are butt welded with a 2 sec flash at 600 kVA

The junction is effected manually, the two ends being clamped in position at a small welding station and joined by electric arc welding. It is then ready to be run through the succeeding automatic section of the line.

The strip passes through a set of power-driven pinch rolls which serve to maintain it in tension during its passage through the shot-blasting plant. This is a Wheelabrator six-wheel unit, bombarding the strip with No. 40 round malleable iron shot from above by three wheels and from below by three wheels.

What would appear to be a guard rail running alongside the Wheelabrator and adjacent machines is actually an overriding control member. At any point along its length it can be gripped and given a twist through a limited angle to stop or start this entire section of the line. Apart from its regular use, when joining coils of material, it provides a convenient grab switch for use in emergency if any machine in the section should malfunction.

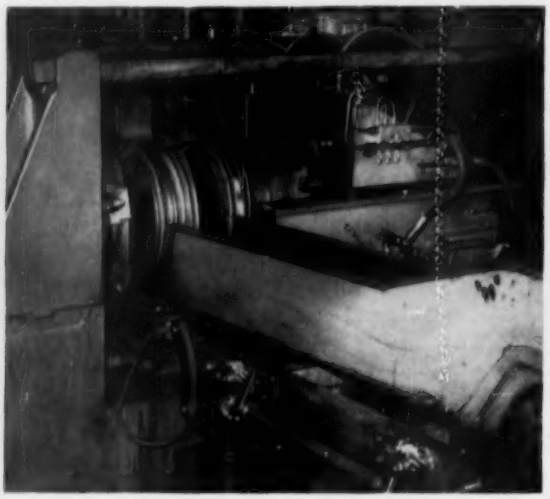
A nine-roll flattening machine draws the strip through the Wheelabrator at the rate of 60 ft/min and delivers it to the flying shear where it is cut to precise length for the rim being produced. The strip is fed through the shear until it trips a limit switch which starts up the press mechanism. As the press head descends, the shearing tools are driven forward pneumatically at a speed synchronized with that of the strip. Simultaneously with the shearing operation the strip is marked with identification characters and rim dimensions.

After shearing, the detached strip is pushed forward, dropped on to a fast-running rubber belt conveyor, and carried to a set of rolls that feed it to a circling machine. Both these machines are started up by means of a switch actuated by the strip while on the belt conveyor. The circled strip is automatically ejected laterally to fall on the platform of a hydraulic lift. In so doing it trips a valve and the lift raises the circle and delivers it to a long inclined chute down which it rolls to the welding machine.

This section of the line cannot be operated uninterruptedly, since stops must be made four or five times each hour to join up a new coil of material. The designed maximum capacity of the line is 600 rims per hour, but this first part

Burr-shearing and weld-rolling machines for dressing the weld

Rims are sized and trued on a Gratnes expanding machine



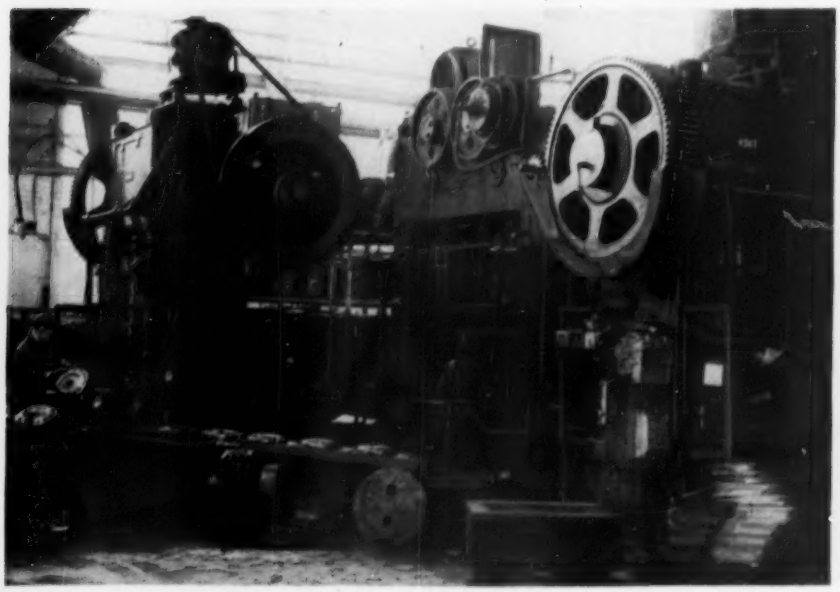
Battery of three form-rolling machines with automatic work transfer

of the line is run at a rate equivalent to an output of 700 circles per hour. During operation, therefore, it over-produces and yields a surplus that is consumed whilst the section is stopped, thus enabling the remainder of the line to be operated continuously. Surplus circles are temporarily stored in the gravity chute and in a rack arranged below it.

Circles are welded on a 600 kVA A1 flash-butt welding machine, being given a 2 sec flash. Although the machine automatically clamps the work, it is at present loaded and unloaded manually. Unloading, however, will soon be mechanized by means of an automatic ejection device. From the welding machine the circle is passed to a "burr-shearing" machine on which the inner and outer faces of the weld line are machined by a pair of wide-faced tools in a single stroke, in the manner of a shaping machine. Thence it is passed to a weld-rolling machine where the machined weld is rolled down to the material thickness in a single pass. This machine, also, is shortly to be fitted with an automatic unloader.

Any variation of strip width, arising from the manufacturing tolerance of $\frac{5}{16}$ in on the rolled material, will result in stepped edges at the welded junction. Previously such imperfections were dressed by means of a hand grinder, but recently a duplex grinder has been introduced into the line for this purpose. The spacing of the grinding wheels is adjustable to suit different circle widths. After trimming on this machine the circle is passed through a spray-type cooling tunnel to a gravity chute by which it reaches the next automatic section.

A group of five machines is used for the cold-rolling of the rim profile and the sizing of the rim. It comprises one British, three German, and one American machines, and is



Blanking and forming presses at the commencement of the wheel-centre line

Wheeel centre and rim are assembled on a 500 ton press

typical of the firm's policy of selecting machines and methods, after careful study, for their functional suitability and capacity. The section is completely automated as regards loading, machine operation, unloading, and transfer to the following machine.

A circle is released from the chute to fall on the loading station of the first machine, a Scriven preform press. Two horizontally opposed, laterally disposed tools are advanced towards each other and pick up the circle. The tools are coned and formed with shoulders which determine the width and uniformity of the preformed band for subsequent operations, despite the possible variation of strip width already mentioned.

Forming is done in three stages on a battery of rolling machines. These are all of the same type having a divided bottom roll. The inner half of the roll is driven and when the halves approach each other to take up the preformed circle the outer half is clutched to take up the drive. On the machine column, above the bottom roll, is a power-driven bull roll and two freely running guide rolls, all mounted on a common vertical slide. The bull roll is adjustable for height and angle, being mounted on a self-aligning bearing on the driving side and an eccentric bushing on the free side. Guide rolls are independently adjustable for both height and angle.

Transfer of work from machine to machine is by three elevating chutes actuated by eccentrics driven through worm gears from a common shaft immediately above floor level. Each chute receives a rim from the preceding machine, holds, elevates, and delivers it to the succeeding machine. After being rolled the rim is ejected to a pivot-mounted lifting lever which throws it into the next chute. Between the first and second of these rolling machines the rim is carried through a tunnel in which it is sprayed with soluble oil.

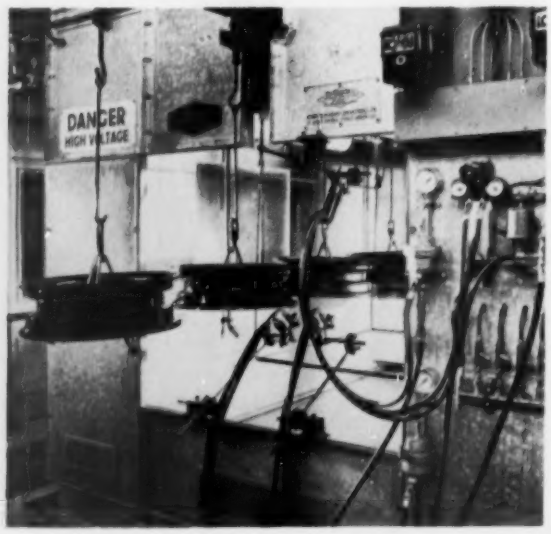
The last elevating chute delivers the rim to a Grotnes expanding machine. This is actuated by four hydraulic cylinders and has two laterally disposed expansible segmental dies. One die is supported from a fixed abutment by a hydraulic cushion cylinder while the other is carried on a hydraulically operated slide. When the slide is advanced and the rim is supported in the dies, the main expander core is advanced through the moving die and enters the stationary die to expand the segments of both simultaneously. The rim is thus sized and trued to the specified diameter. On withdrawal of the core the die segments are retracted by their individual springs and when the moving die pulls out on its slide the rim is released to an unloading chute.

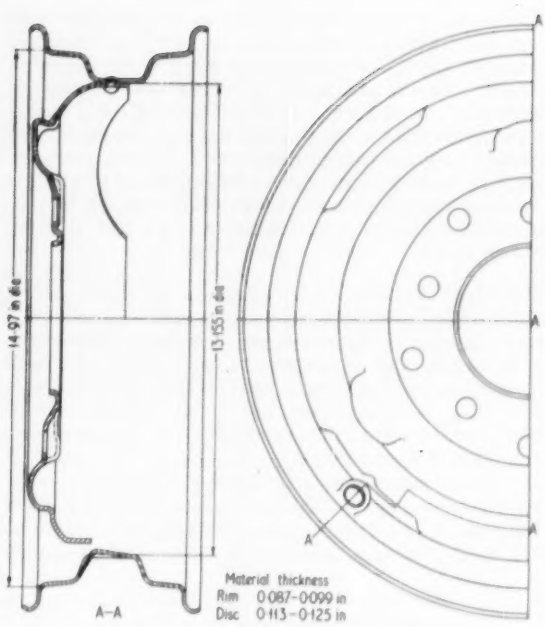
Thereafter, it is manually progressed through two small presses to form the depression for the valve and to pierce the valve hole. It is then passed to an inspection bench where it is examined for defects or abrasions and percentage checked for diameter by gauging the circumference of the well and of the tyre seat. Rims are then hung on a continuously moving overhead conveyor for transfer either to stores or to the assembly line.

As noted earlier, the line can be operated at a rate to produce 600 rims per hour. At present, however, it is being run at the economical optimum of 80 per cent efficiency, giving an output of 480 rims per hour, and a double shift is being worked. At whatever rate the line is operated to meet a current demand, the roll-forming machines are run at a constant speed to maintain the peripheral rolling speed. Adjustment of through time to conform to the rest of the line is effected by speeding up or slowing down the transfer mechanisms.

A battery of five presses is used for setting rivets

Primer is applied in electrostatic spray booths





Section and elevation of a typical pressed wheel for a series-production car

Since the line must handle a fairly wide range of rim sizes and patterns, it is laid out to facilitate changes of tooling. In practice, a changeover can be made in approximately three hours. Under normal conditions a set-up is made for a run of 20,000 rims as a minimum, but shorter runs may be undertaken for proving, or for special types, or under special circumstances.

Wheel centre line

Arranged parallel to the rim line is the wheel centre line. At present the presses are manually operated and work is transferred mainly on roller conveyors. It has now been re-planned and shortly will be laid out with some new presses and automatic loaders, unloaders and transfer mechanisms.

Under existing conditions the stock plates are cut on a Pratt guillotine shearing machine to sheets of a size adequate for two wheel centre blanks and are stacked on stillages alongside the first Craig & Donald 250-ton blanking and forming press. From this machine the blank is transferred on a slat-type conveyor to a similar 250-ton press for depression of the centre area and formation of five depressions which serve as stiffening ribs in way of the brake-adjustment holes. It is then passed to a Wilkins & Mitchell 250-ton press for further development of the peripheral form and for forming the hub-cap depressions. Next it goes to another Craig & Donald press for the piercing of the central aperture and, in this instance, five stud holes and five brake-adjustment holes. Finally, it is finish formed on a Clearing 650-ton press. All stud holes are cleared on a single-spindle drill.

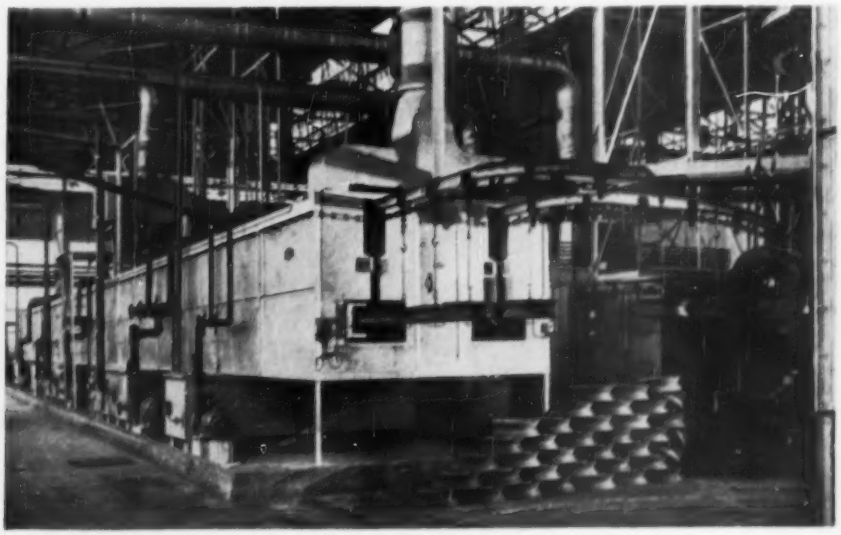
Wheel assembly

From the Clearing press the centre is manually transferred to a Wilkins & Mitchell 500-ton "push-on" press for assembly in a rim. The centre is loaded by one operator from the rear of the press, and is located by stud holes engaged over three dowels on the die. Stationed at the front of the press, a second operator places a rim in position over the centre, aligning the valve hole relative to the centre by sight, and operates the press. The two parts are forced into engagement with an interference fit, and in the same operation the stud holes are embossed and the central aperture is drifted.

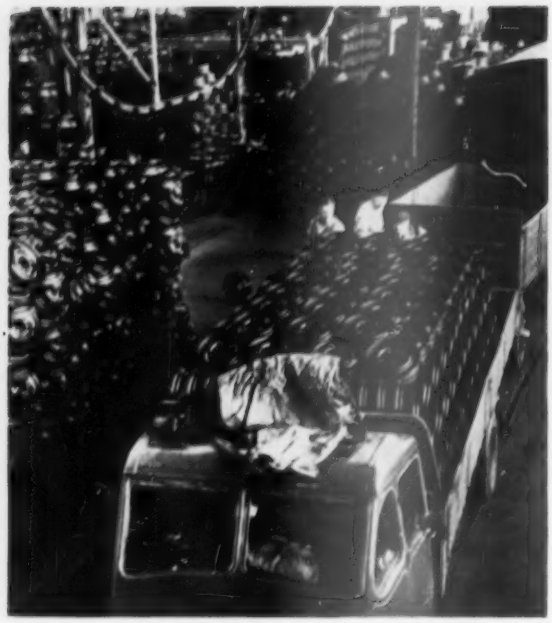
Rims for assembly are brought on the overhead conveyor and are unloaded into a gravity chute down which they are delivered to the press. The assembled wheel is unloaded into a chute and passes to a spot-welding machine where three spots are made to secure the two parts in position and obviate the possibility of inadvertent movement during subsequent operations. After welding, the wheel is returned to the overhead conveyor and transferred to the Noble spray-type pre-cleaning plant.

The conveyor carries the wheel through the four sections of the plant in approximately seven minutes at a speed of 11 ft/min.

1. Degreasing with hot water and a small addition of wetting agent, at 130 deg F and 10 lb/in² pressure.
2. Cleaning with alkaline solution, at 180 deg F and 40 lb/in² pressure.
3. Rinsing with cold water, at mains temperature and 30 lb/in² pressure.
4. Rinsing in dilute phosphate solution, at 140 deg F and 30 lb/in² pressure.



Parallel conveyor lines for car and tractor front wheels traverse the phosphating plant



One of the two dispatch docks arranged for road and rail transport

The track loops on leaving the plant and the wheel is air dried as it is returned, alongside the plant, to the assembly line. After unloading, the valve hole is countersunk, and the wheel is placed in a chute which feeds a line of four pedal-controlled punching presses. Twelve rivet holes are punched individually through the rim and the centre, in groups of three holes in each of the four peripheral contact areas. At each of these presses the operator picks a wheel from the delivery chute alongside and, when punching is completed, places it in a parallel chute for transfer by gravity to a line of five pedal-controlled riveting presses.

On each of these machines a seated operator lifts a wheel from the chute, inserts three rivets by hand and sets each by a single stroke of the press. The operation is repeated until all twelve rivets are set and then the wheel is dropped into a chute which delivers it to the end of the press line where it is picked up by a slat conveyor and raised to an inspection bench. A 100 per cent inspection is maintained; the material is examined for cuts, abrasions or laminations likely to form stress-raisers or to initiate cracks. Riveting is examined and the wheels are spun on a spindle to check for lift and run-out. Any wheel having a minor, non-critical defect is passed to an adjacent rectification bench. After correction, it is returned to the conveyor and again submitted to the full inspection routine.

Phosphating plant

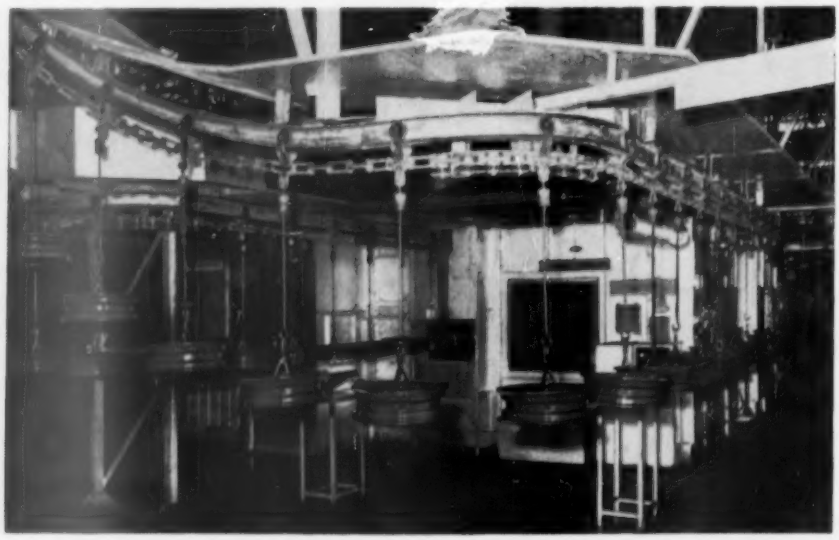
From the final inspection bench wheels are transported on the overhead conveyor to the phosphating plant. Two conveyor lines traverse the plant; a car wheel line at a speed of 20 ft/min and a tractor front wheel line running at 7·5 ft/min. Through time for the car wheels is about seven minutes. The process comprises five spray treatments in the following sequence:

1. Dilute wetting agent, 130 deg F at 10 lb/in².
2. First phosphating solution, 140-160 deg F at 25 lb/in².
3. Second phosphating solution, 140-160 deg F at 25 lb/in².
4. Rinsing with cold water, at mains temperature and 30 lb/in².
5. Corrosion-inhibiting rinse with dilute phosphoric and chromic acid solution, 120 deg F at 30 lb/in².

On leaving the phosphating plant the wheel is conveyed to a drying-off oven, oil fired to maintain a temperature of 300 deg F. The track has three loops in the oven and the through time is five minutes. Next it is carried through a cooling tunnel in which there is a forced circulation of shop air. It is then conveyed under the shop roof trusses for a period of about 12 minutes and delivered to the first priming booth at a temperature not exceeding 70 deg C.

Priming Plant

The booths are equipped for electrostatic spraying on the Ransburg No. 1 system. The wheel is suspended on a rotatable hook and the track is furnished with the necessary friction material-faced rail to ensure rotation of the work as it traverses the booth. In the spraying area the wheel passes between three spray guns, arranged two below and one above the wheel. At the exit from the booth is a single automatic traversing gun spraying across the upper surface of the wheel



General view of electrostatic spray booths and canopied conveyor lines

to ensure coverage of the recess between the rim and the centre.

Outside the booth the conveyor loops and then returns to the second booth; the wheel spending about 1·5 minutes in the shop air to flash-off the first coating. It then enters the second booth which is equipped with two spray guns, one above and one below the wheel. Here the coating is built up to a thickness of 0·001 in. Then follows a second flash-off period of 3 minutes and the wheel is elevated to the stoving oven which is located above the drying oven. Stoving temperature is 400 deg F and the wheel is passed through the oven in nine minutes.

Wheels are finished with a chocolate-coloured primer only, and are painted as required at the car manufacturer's works. The priming plant is operated on a single-shift basis only. Night-shift production is stacked on the shop floor adjacent to the lower run of the conveyor and is on-loaded during the day shift to fill in gaps in the line of work entering the first booth.

Primers are supplied from a remotely sited mixing room, where paints for tractor front wheels are also mixed. This plant handles primers from two 750 gal tanks, thinners from two 750 gal tanks and five different colours from drums. It is equipped with twelve 75 gal mixing machines into which primers and thinners are directly metered. Primers and paints are piped and circulated to the spray booths.

Wheels leaving the stoving oven are conveyed in the shop at high level for about 15 minutes before being off-loaded at two large dispatch docks. These docks are laid out with sunken rail tracks to permit use by both railway wagons and road vehicles. Methods of transport vary with customer's requirements. Some are merely stacked in the wagon or vehicle while others are clamped on tiered stillages. Even wheels for transport overseas are, in some instances, dispatched loose and are merely stacked in the ship's hold.

Wheelmaking is a highly specialized and a highly competitive large-scale industry. Its productive efficiency is necessarily continually under review. Mechanization and automation, where possible or where practicable, is introduced and used to full advantage. The benefits of such intensive production are not localized or one-sided, but are of general advantage. The firm is rightly proud of the fact that, despite the vastly changed economic conditions, they can still supply to manufacturers a set of five modern wheels for a series-production car at approximately the same cost as applied in the 1920 period after World War I for a set of five steel artillery wheels.

OILLESS BALL JOINT

A New Track-rod Joint with Steel to Nylon Bearing Surfaces

THIS is the first example of a range of ball joints about to be introduced by Chorley Precision Engineering Ltd., of Avenue Works, Chorley, Lancashire. Instead of the usual solid-ended ball stud, it has a half-ball of steel and is completed by a separate hemisphere of nylon. The plane face of the nylon member is recessed to accommodate a conical compression spring which tends to separate the two parts.

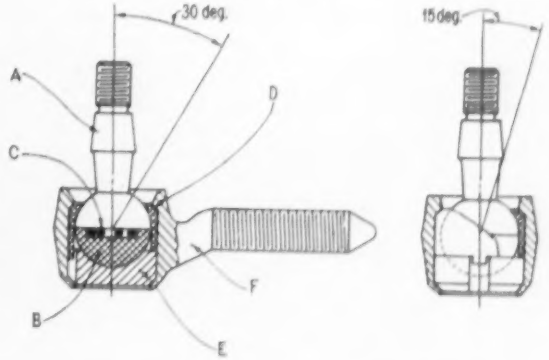
The steel half-ball seats in a nylon bushing and the nylon half-ball is supported by a steel end cap. A tongue on the nylon bush is engaged in a groove in the steel cap to prevent relative movement. When the lower peripheral margin of the body is spun over the steel cap on assembly, metal flows into the groove and prevents movement between the cap and the body. It is not clear whether means are provided to obviate the possibility of movement between the two half-balls.

Several advantages are claimed for this new joint. It is smooth in operation, completely eliminates the need for lubrication and, within certain limits, is self-adjusting. Due to the resilience of nylon, tight loading on assembly and the slight misalignments arising from manufacturing tolerances are automatically accommodated. The nylon elements also tend to reduce the transmission of road shocks through the steering linkage.

The joint has been exhaustively rig-tested under a variety of severely adverse conditions. After copious applications of abrasives and contaminants, it was found that hard foreign matter had become innocuously embedded in the nylon instead of remaining between the bearing surfaces. Steel bearing surfaces, it should be noted, are induction hardened. It is stated that after road-testing on a vehicle for more than 20,000 miles, no measurable wear could be detected.

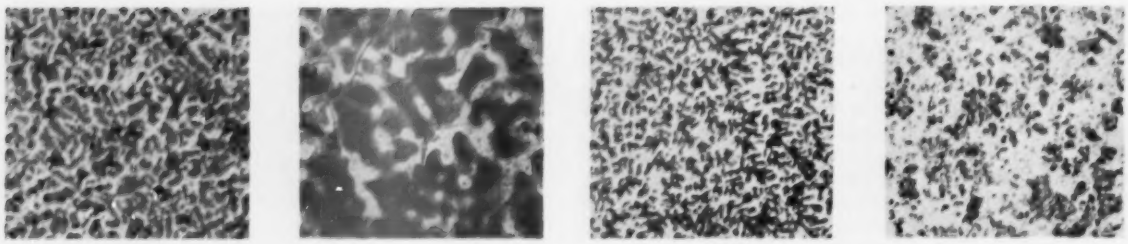
To be designated the Z-type joint, it will as regards costs, be strictly competitive with the firm's conventional solid-ball joint. Economies arising from the elimination of such items as the drilling and tapping for lubrication nipples compensate for the additional cost of the nylon. The present joint has a ball of 1·0 in diameter, but the range will eventually extend from 0·75 in diameter to 1·5 in diameter.

Another application of the Z-type joint is for the ball-ends of independent front suspension wheel carriers. These would necessarily be of larger size and would be produced to meet specific requirements. Use of the joint for both steering and suspension presents the possibility of eliminating grease nipples from the front end of the vehicle.

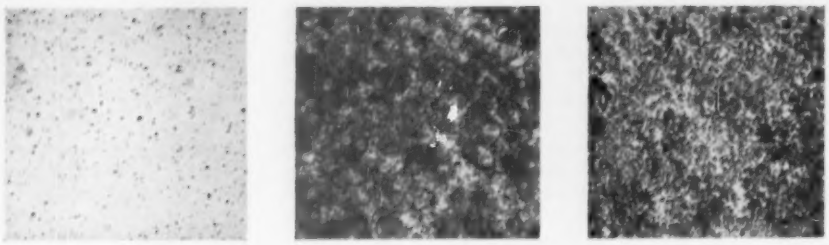


A—Ball stud
B—Nylon half-ball
C—Spring
D—Nylon bushing
E—Steel cap
F—Body

The Z-type oilless track-rod joint



a *b* *c* *d*



e *f* *g*

Photomicrograph of Main Metal in various forms. All except e, which is unetched, are etched in 10 per cent NaOH, at 70 deg C, and the figures in the key are approximate magnifications

a Sand cast, 37½; b sand cast, 225; c gravity die cast, 37½; d pressure die cast, 37½; e as extruded, 56; f as extruded, 225; g as extruded and rooled, 56

MAIN METAL

A New Aluminium-Zinc Alloy Suitable for Extrusion and Sand and Die Casting

AN aluminium-zinc alloy, suitable for a wide range of applications, has been introduced in this country by Main Metal (Great Britain) Ltd., of 71, Monmouth Street, W.C.2. The sole manufacturers of this alloy are International Alloys Ltd., of Aylesbury, Bucks. It is the policy of the Main Metal Company to supply the metal in ingot form, but if special components are required, arrangements have been made for a number of well-known foundries, at convenient points thoughout the country, to undertake their manufacture on behalf of consumers.

The advantages of the material are as follow. It is light, its specific weight being less than half that of bronze. Components, such as brake pedals, can be die cast from the material and do not require bushing because Main Metal has good bearing properties; also, components manufactured in this way have a good finish. The metal is easy to machine and can be threaded without tearing. It is superior, so far as strength is concerned, to most of the commonly used alloys for die casting. Since the metal has good bearing properties, it is particularly suitable for worm wheels, as well as synchro cups. Because of the strength of this material, it does not need a steel backing when used in bearings. Last, but not least, among the advantages, is price stability; it is claimed that material changes in price are not envisaged in the foreseeable future. Its price is approximately 2s 3d per pound, which, of course, is considerable cheaper than that of most other bearing metals.

Other metal-producing firms have experimented with alloys of this type, but have not found it easy to eliminate porosity. Main Metal claim to have overcome this difficulty by the employment of special foundry techniques, which include the use of special fluxing and degassing agents. Moreover, they are now able to extrude the material. For pressure die casting, a typical analysis of Main Metal is:

Cu	2·8 per cent	Mn	0·04 per cent	Si	0·52 per cent
Fe	0·17 „ „	Mg	0·02 „ „	Ni	0·02 „ „
Pb	0·04 „ „	Ti	0·02 „ „	Sn	0·02 „ „
Zn	59·2 „ „	Remainder aluminium			

The percentages of the constituents of the alloy are varied slightly according to the manufacturing processes to be used; for example, in chill-cast form, the percentages are much the same, except that only 1·9 per cent of copper is included and the zinc content is 52 per cent.

The principal physical properties of the material are as follow: specific weight 3·8-4; shrinkage 1·5 per cent; shrinkage, in pressure die casting, 0·8 per cent; linear coefficient of thermal expansion 23×10^{6}/deg C. The mechanical properties vary according to the form in which the material is supplied. For sand or chill casting, an ultimate tensile strength of 22 ton/in² is quoted, and the 0·1 per cent proof stress is between 15·6 and 15·04 ton/in²; the elastic modulus is $9{\cdot}8 \times 10^{6}$. On a length of 2 in, an elongation of 3 per cent for sand castings and 1 per cent for chill castings is quoted. The VPN (10 kg) hardness value is between 105 and 119 for sand castings and is 110 for chill castings. Other data for castings are as follow, the first of each pair of figures being for sand castings and the second for chill castings. Under compression loading, the limit of proportionality is 19·2-21·0 ton/in² and the 0·1 per cent proof stress is 22·1-24·0 ton/in². An ultimate cracking stress of 43-41 ton/in² is quoted, and the elastic modulus is $3{\cdot}5\text{-}3{\cdot}9 \times 10^{6}$. At failure, the height reduction is 52·5-55·5 per cent and the diameter increase is 46-53 per cent. Pressure die castings are said to have an ultimate tensile strength of 35 ton/in², a yield point of 32·9 ton/in² and an elongation of 3 per cent on a 1 in long test specimen.

Extruded hexagonal bar, measuring $\frac{3}{8}$ in across the flats, has been found to have the following properties: Brinell

hardness (1,000, 10) 134; elastic limit 16·6 ton/in²; 0·1 per cent proof stress 25·4 ton/in²; ultimate tensile strength 30·5 ton/in²; elastic modulus $10{\cdot}3 \times 10^6$; elongation on a 2 in long specimen 17·5 per cent; reduction in sectional area 43 per cent; Izod impact 3, 4, 4 lb-ft. In compression, the 0·1 per cent proof stress is 25·8 ton/in², the elastic modulus $5{\cdot}0 \times 10^6$, and the elastic limit is 18·7 ton/in². The material can be annealed by heat treatment at 170 deg C.

When the material is used for bearings, it is stated that for a linear speed of 1,380 ft/min, the nominal pressure can be as much as 3,400-3,700 lb/in², if unhardened shafts are used, and 7,000-10,000 lb/in² with hardened shafts. The bearing clearance specified is 2D/1,000, where D is the shaft diameter. However, it has been found that with good machining and proper lubrication, smaller bearing clearances can be adopted.

The cutting speeds for machining Main Metal are in general higher than for other copper alloys. It is preferable to use lathes with direct drives. For rough cuts, speeds of between 325 and 820 ft/min are recommended and for finishing cuts, it is suggested that speeds of 650-2,500 ft/min are adopted. In each case, the higher figures are for carbide-tipped tools. These figures, of course, are only intended as a rough guide, because cutting speed is, to a certain extent, dependent on the type of tool and lathe used.

It is suggested that the following cutting angles should be adopted: front rake 18 to 22 deg; tool angle 26 to 72 deg; and top rake 0 to —3 deg. It is advisable to use cooling liquids when turning Main Metal; paraffin is recommended as being particularly suitable, but most of the commonly used liquids can be employed. For grinding, the abrasive discs should be of ceramic-bonded silicon carbide with a grain size of 46. The hardness recommended is K. Conventional grinding oil emulsion is used for cooling.

New Plant and Tools

Recent Developments in Production Equipment

MANUFACTURE of the Renault-designed electro-mechanical unit heads, that were developed in France, has been undertaken by Sentinel Ltd. of Shrewsbury. The Sentinel-Renault units, embodying the production experience of both companies, make use of a basic form of construction consisting of a headstock operated by two motors mounted on a sub-slide. The main motor provides the drive to the spindle and the cutting-feed traverse, while the second motor drives a feed screw that controls the rapid-approach and withdrawal part of a work cycle. A wide range of speeds and feeds are obtainable by the use of change gears, all of which are totally enclosed and lubricated by a pump.

An electro-mechanical disc brake, used for stopping at the end of a work cycle, is built into the fast traverse motor and operated from the A.C. mains supply. With this arrangement it is unnecessary to provide additional switch equipment for the brake, since when the motor is "on" the brake is held out of engagement. At present the heads are manufactured in three sizes EMH10; EMH20 and EMH30 having power outputs of from 1½ h.p. to 10 h.p. Each can be mounted on slides of different lengths.

The spindles are mounted in taper-roller bearings at the front of the headstock and cylindrical-roller bearings at the rear and are driven by spur gearing at speeds from 90 to 1,460 r.p.m. depending upon the size of unit. The feed screw also controls the movement of a sequence cam giving as many fast and feed traverses as required, combined with a rapid-return stroke at the conclusion of a work cycle. A pneumatic counterbalance is used in the heads to enable them to be mounted horizontally, vertically or at an intermediate angle, according to requirements.

As distinct from the manufacture of unit-heads as the operative component of a machine, the Company has commenced the production of a number of constructional members such as wing-bases, columns, centre-hubs and rotary tables, from which it is possible to build-up a machine to suit a specific workpiece. By adopting this method of producing the essential framework of a machine it is estimated that, in the event of the machine becoming redundant due to a change in production schedule, some 60 per cent of the standard constituent parts can be incorporated into a new machine. An example of this type of fabrication is seen in

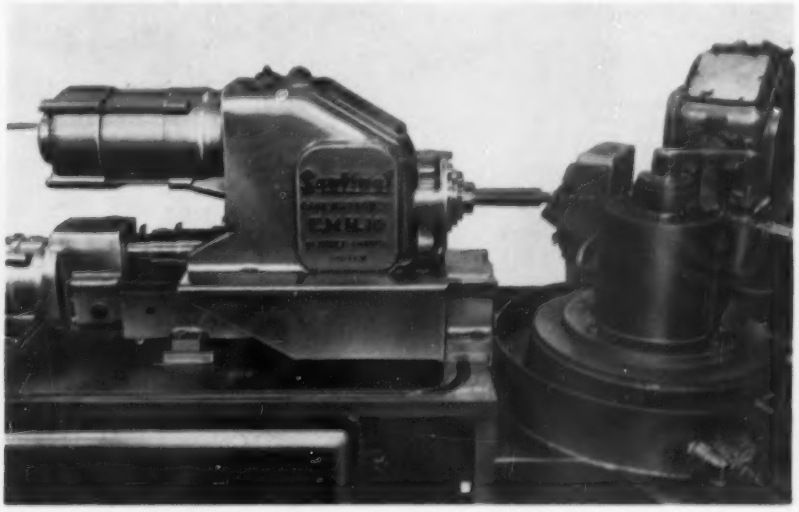


Fig. 1. Sentinel-Renault electro-mechanical unit head on three-way drilling machine
Sentinel Ltd.

Fig. 1, which shows two units of a three-way horizontal drilling-machine. This machine consists of three bases and three EMH10 unit-heads arranged around a centre-hub. As, in this instance, the hub and the spacing of the heads is special to the component to be machined, the hub has been fabricated instead of being produced as a casting.

Tangential-nozzle spray gun

A new development in spray gun nozzle design has recently been introduced by Alfred Bullows and Sons Ltd., of Long Street, Walsall, Staffs. Known as the tangential nozzle, it represents an important step in obtaining the maximum conversion of the energy of the air passing through the ports to produce a fan-shaped spray.

In conventional nozzle design the air ports are opposed, so that the two airstreams impinge upon each other, and in so doing most of the energy is dissipated. With the new arrangement of the nozzle horns, the kinetic energy of the discharged air is used to the full as the two airstreams pass tangentially across the face of the nozzle. A gun fitted with the new nozzle is shown in Fig. 2.

This development allows a very wide spray and maximum coverage per pass of the gun, while breaking up a given amount of paint with a reduced consumption of air at a lower pressure. Quite substantial economies can be obtained for certain application, particularly with electrostatic deposition, and it is often possible to reduce atomizing air pressure from 50 lb/in² to 5 lb/in² and at the same time to obtain improved performance. The tangential nozzle is suitable for use with Bullows L/200, L/500 and L/600 guns, and is interchangeable with other pressure-feed set-ups on these guns.

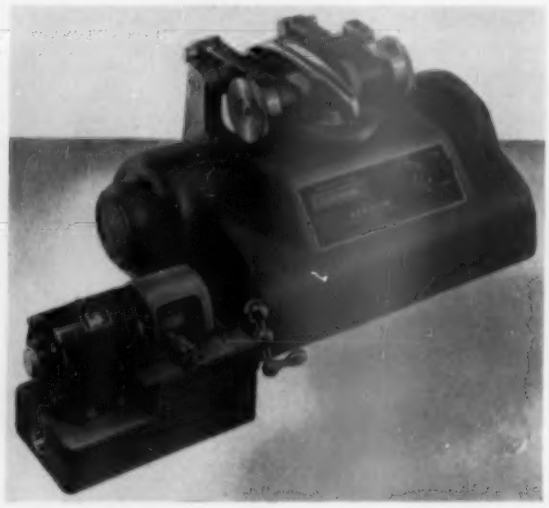
Fig. 2. Spray gun with tangential nozzle
Alfred Bullows & Sons Ltd.

Abrasion evaluation

The American-built Taber standard abrasion testing set, Fig. 3, designed to evaluate the resistance of surfaces to rubbing abrasion, is now factored by Funditor Ltd., of Woodbridge Street, London E.C.1. Its range of application covers investigations on painted, lacquered and electroplated surfaces, plastics-coated materials, textile fabrics from sheer silks to heavy upholstery, metals, leather, rubber, and linoleum.

A rotary rub-wear action is generated for test purposes by dual abrading wheels, one of which rubs the specimen from the centre outwards, and the other from the outside towards the centre. The abrasion marks are, therefore, in the form of a cross-over pattern and cover an area of approximately 30 cm². The wheels traverse a complete circle on the specimen surface and, in so doing, reveal the abrasion resistance at all angles relative to the weave or grain of the material. Three standard ranges of wheel pressures are used for determining the life of a surface.

Fig. 3. Taber abrasion testing machine, with abrasive wheel resurfacing unit alongside
Funditor Ltd.



A wide range of accessories is available for use with the equipment to enable qualitative and quantitative wear to be examined. For example, in judging the quality of the material from the standpoint of abrasion resistance, a wear factor is calculated, which represents the loss in weight per 1,000 cycles of test under a specified set of conditions. Quantitative or total wear, such as that of a protective lacquer, is indicated by the counter reading at the first sign of penetration of the material. A cycle selector is used for these tests and this is calibrated in units of 10, 100 or 1,000 cycles. When a long-term test is required, the unit is set for continuous operation and the cycle readings obtained from the counting head.

Two basic types of abrasion testing wheels are used, consisting of Calibrade, which is a hard vitrified material, and Calibrase, which is a resilient material. Both of these are trued from time to time on the diamond-point resurfacing unit, shown on the left-hand side of the test equipment.

Wet-belt grinding

Wet-belt grinding is a rapid method of machining and is one that can, in certain instances, replace other methods of working, such as shaping and milling, with considerable savings in labour time. Owing to the low cutting pressures, fragile work can be accurately machined without danger of distortion and the entire surface area or areas to be ground can be introduced to the abrasive surface simultaneously.

A new machine in this category is the Taylor 9 in wet-belt grinder built by Taylor Tools and Supplies Ltd, of Vortex Works, Broadheath, Altrincham, which has been designed to obtain the maximum efficiency from electro-coated, resin-bonded abrasive belts. The machine is shown in its basic form in the accompanying illustration, Fig. 4, fitted with a hand-operated, micrometer-stop, adjustment table. Automatic work-fixtures or a plain fixed table can be fitted if required. One of the features of the design is that the abrasive belt pulleys, both driving and idler, are supported

at both ends by ball and roller bearings which are protected by labyrinth seals.

The endless belts are 108 in long and are driven at speeds between 2,500 and 5,500 ft/min according to requirements: handwheels are provided for tensioning and tracking of the abrasive belt. When the machine is to be used for free-hand grinding, the manufacturers recommend the use of a 5 h.p. motor; when the micrometer-stop table or automatic fixtures are used the power should be increased to 10 h.p.

The base of the machine forms a 75 gal capacity coolant settling-tank and has multiple compartments to allow the fluid to settle-out before it is recirculated. A removable, drawer type collector is used for trapping the heavy swarf before it can reach the tank. A motor-driven centrifugal pump is contained in one compartment of the tank, and this directs coolant to three points. The first is above the work for cooling purposes, the second is directed at the back of the abrasive belt to help lubrication as the belt passes over the plates, and the third passes below the work table.

Three-dimensional profiling

From time to time in recent years, a number of developments have taken place in this basically die-sinking sphere of machining to produce semi-automatic or, in some instances, fully automatic equipment capable of accurately reproducing a three-dimensional form from a steel, wood or plaster model of the part required, using a variety of copy-profiling techniques. The Pratt and Whitney Velvetrace miller, Fig. 5, is a new machine in this category, and makes use of an ingenious system of tracer control. Pratt and Whitney (Division Niles-Bement-Pond Co.) are represented in this country by Buck and Hickman Ltd, Machine Tool Department, Otterspool Way, Watford, Herts.

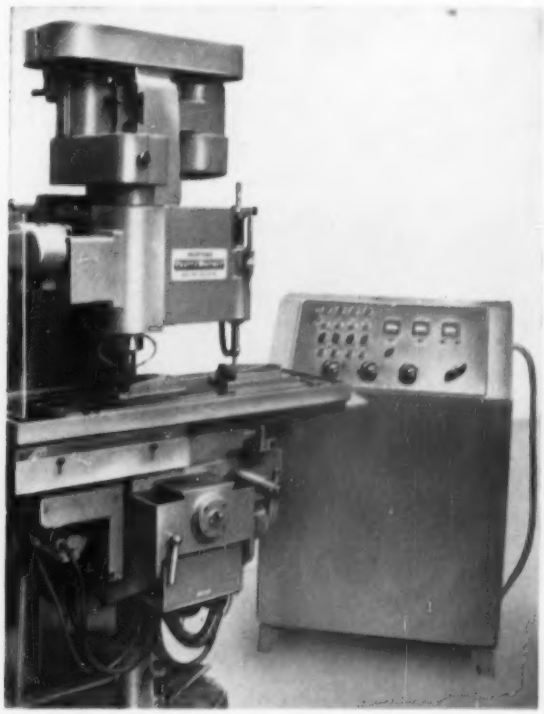
The machine is arranged to duplicate the master form by a series of traces, either longitudinally or transversely. The length of stroke in either direction is set by limit stops, and the tracer, following the contour of the model, controls the direction and speed of the vertical motion of the cutter-spindle quill and the rate of travel of the table or carriage. After each pass, a predetermined incremental step-feed is applied, and this continues until the complete surface of the model has been duplicated. The table has a longitudinal working traverse of 12 in and a cross traverse of 9 in, which corresponds to the largest planform dimensions of the part that can be reproduced. During a profiling operation, the cutter and tracing spindles have a vertical travel of $3\frac{1}{2}$ in, and the knee a vertical adjustment of 13 in.

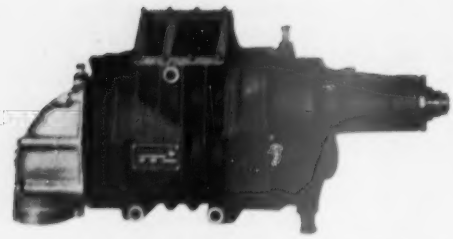
The tracing system makes use of a spark gap between the stylus and model so that there is no actual contact. That is to say, the tracer follows the contour without actually touching it: the spark gap is maintained between the two and controlled to within an accuracy of approximately 0·001 in. A high-voltage, low-amperage current is applied to the tracer point and, as the point is advanced towards the model, which is earthed, a spark jumps across the gap. The voltage set up in this way across the gap is applied in the associated electronic circuit to measure its width and electronic anticipation circuits measure any rate of change in the width. By this means, the slightest variation in spark gap width produces a proportional change in the voltage across the gap, which is instantly amplified electronically and is used to control the drives to the spindle quill and longitudinal or traverse motions of the table.

The spindle quill is driven through a pair of contra-rotating magnetic clutches which engage armatures that are individually connected to a spindle rack by pinions. Motion occurs when the control increases the torque of one magnet and decreases the torque of the other, causing one to be driven and the other to slip. The slipping magnet never completely disengages, and retains contact with the rack at all times. This opposed-drive system provides maximum sensitivity with continuously variable speed control of 0–20 in/min for table slides and 0–18 in/min for the vertical movement of the cutter and tracer spindles.

Fig. 4. Taylor wet-belt grinding machine
Taylor Tools and Supplies Ltd.

Fig. 5. Pratt and Whitney Velvetrace profile milling machine
Buck and Hickman Ltd.

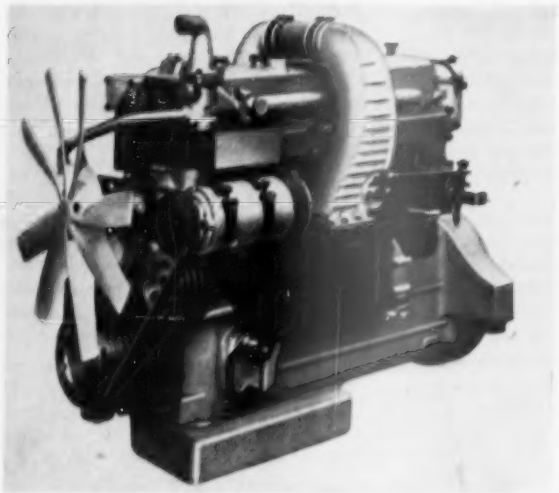




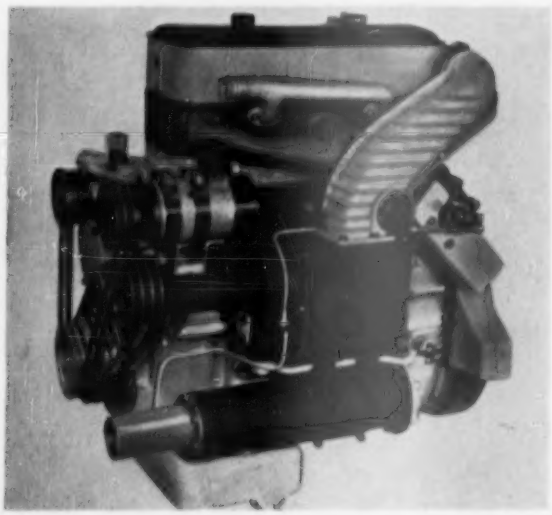
So far as external appearance is concerned, the Saurer positive displacement blower is similar to the Roots type, but the arrangement of the inlet ports is different

SAURER SUPERCHARGER

A UNIT OF THE POSITIVE DISPLACEMENT TYPE, WITH HELICAL LOBES



Two Saurer in-line engines equipped with the new blower installation. Above is the CT2DLm six-cylinder unit and below is the CR2DLm four-cylinder engine, both of which are in production



FOR some years, Aktiengesellschaft Adolf Saurer, of Arbon, Switzerland, have been developing a helical-lobe blower of the positive displacement type. The aim has been at producing an engine-blower combination with a torque output that does not fall as the engine speed is reduced under load. This ruled out the Roots type unit and dictated the employment of a positive displacement blower. Since the reciprocating type of unit is complex and requires a great deal of space, attention was directed towards rotary compressors. The helical lobe type of compressor proved to be the most promising design, so Saurer concentrated on this type and undertook an extensive development programme on it.

The success of supercharging, of course, depends to a great extent upon the blower characteristics. Volumetric efficiency is important, since it determines the way in which delivery pressure varies as a function of speed. A high overall adiabatic efficiency is another requirement, which is necessary if fuel consumption is to be kept to a minimum. This factor also determines the charging pressure that can be obtained without adversely affecting the fuel consumption. If, for example, the power output of the supercharged engine is to be 30 per cent higher than that of the normally aspirated version, the pressure ratio required is such that the adiabatic efficiency of a Roots type mechanically driven blower is out of the question. Acceptable results, so far as fuel consumption, pressure ratio and torque characteristics are concerned, can only be obtained with a blower of the internal compression type.

A longitudinal section of the blower is shown in an accompanying illustration. From this, it can be seen that the unit is of the Lysholm type. There are two rotors running in opposite directions. Each has three helical lobes the shape of which is the subject of a patent. The main rotor has convex teeth and the teeth of the sealing rotor are concave. The rotors are in a housing, which in form is similar to that used with Roots type blowers. There are exceptionally small clearances between the lobes, which are prevented from contacting one another by accurately manufactured synchronizing gears.

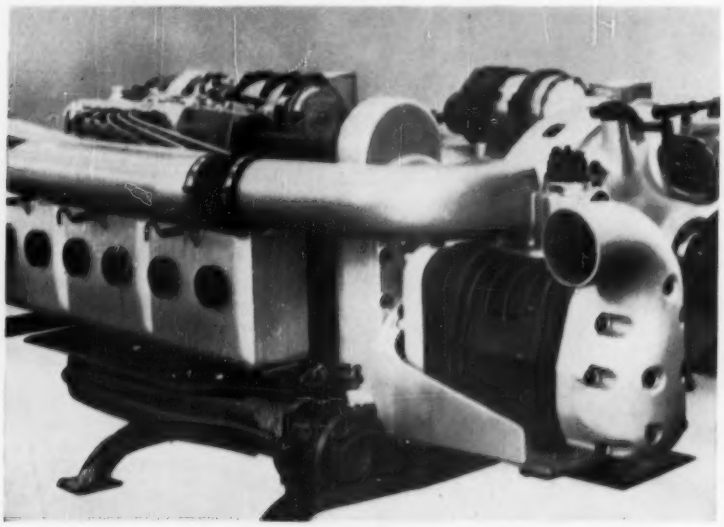
Hitherto, most applications have been to existing engines and therefore the blower has been belt-driven, but with engines specially designed for the blower, a torsionally elastic coupling may be used. When a belt-drive is employed, a high blower : engine speed ratio is obtained by the incorporation of gearing in the end of the blower housing. In this way, excessive belt speeds are avoided, despite the fact that overall ratios of 3 : 1 or 4 : 1 are obtained.

In the illustration of the longitudinal section of the blower, the suction port is on the left. Movement of the rotors uncovers this port, and the air passes through it to fill the space between the lobes. Further rotation of the lobes closes the ports; at the same time, the lobe of the compression rotor enters the cavity of the sealing rotor and compresses the trapped air until the other end of the lobe has rotated far enough to uncover the discharge port. The position of the discharge port, of course, determines the point at which it is uncovered by the lobe, and therefore fixes the compression ratio.

Development work carried out by Saurer has been concentrated mainly on aspects of production. The problem was the design of a lobed shape, that could be produced easily and which, at the same time, would give good volumetric and adiabatic efficiencies. Hollow rotors are employed because they have low inertia and the weight of the unit is substantially reduced. Also, balancing is easier. Solid rotors are difficult to cast in one piece and blow-holes are almost unavoidable. Moreover, they require a larger allowance of material for machining than do hollow ones. The hollow rotors are cast in halves and therefore are easy to form. A cylindrical cross section has been adopted for the lobes because it simplifies machining and enables the profile to be ground accurately to close tolerances at a relatively low cost. This enables the smallest practicable clearance to be obtained between the rotor and the housing, and therefore increases the efficiency of the blower.

At present, Saurer are producing a blower of 1·4 litres displacement for supercharging the CR2DLm four-stroke vehicle engine, with a bore and stroke of 115 mm and 140 mm respectively. Another blower, with a displacement of 2·07 litres, is used to supercharge the CT2DLm six-cylinder engine and the CH2DLm eight-cylinder unit, both of which also have a bore of 115 mm and a stroke of 140 mm. This particular blower has also been applied to a new six-cylinder engine, with a bore of 125 mm and a stroke of 140 mm, which is produced in two forms, designated the Type DC and Type DCU units. In the supercharged and normally aspirated forms respectively, the engines have power outputs as follows: CR2DLm, 120 b.h.p. and 80 b.h.p.; CT2DLm, 175 b.h.p. and 125 b.h.p.; CH2DLm and DCUL,

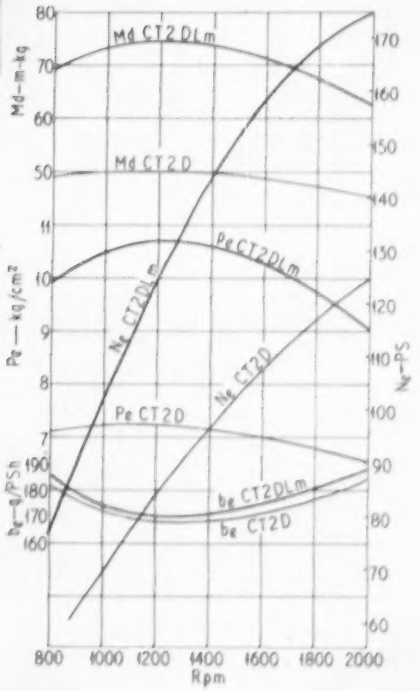
Above: The new blower installed on the Saurer CH2DLm V-eight engine

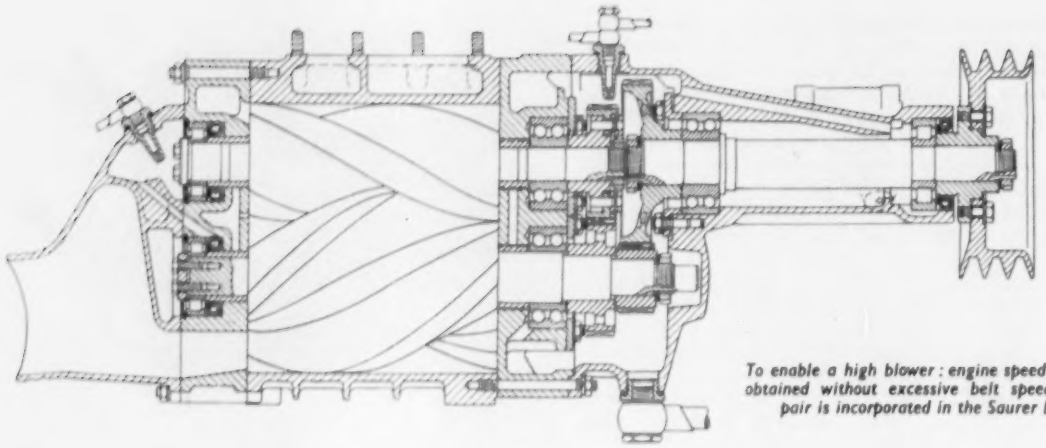


Left: On this engine, the Saurer DCUL underfloor unit, the new supercharger installation incorporates a direct drive

Below: Performance curves of the CT2DLm and CT2D engines, which are respectively supercharged and normally aspirated

be Brake specific fuel consumption
Pe Brake mean effective pressure
Md Torque
Ne Brake horse power



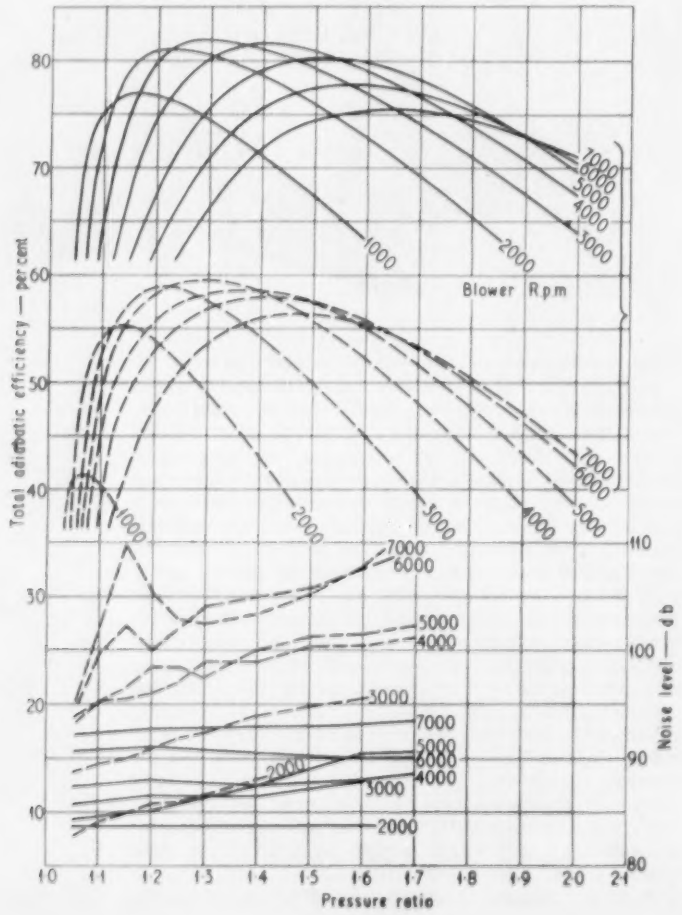


To enable a high blower : engine speed ratio to be obtained without excessive belt speeds, a gear pair is incorporated in the Saurer blower

220 b.h.p. and 160 b.h.p. The last two engines mentioned differ in that the first develops its maximum b.h.p. at 1,900 r.p.m., while the peak output of the second is obtained at 2,000 r.p.m. All the others develop their maximum b.h.p. at 2,000 r.p.m.

The characteristics of the blower for the CT2DLm and CH2DLm engines are shown in the illustration at the end of this article. From this illustration, it can be seen that the overall adiabatic efficiency is good. The steepness of the pressure-volume curves indicates good volumetric efficiencies, as also does the favourable position of the operating line for the type CH2DLm eight-cylinder engine. It can be seen that the optimum adiabatic efficiency of over 78 per cent is obtained over a wide operating range. Over the entire operating range, the total adiabatic efficiency is in excess of 75 per cent, and the charge pressure values obtained

The hollow rotors and their profiles are the subjects of several patents



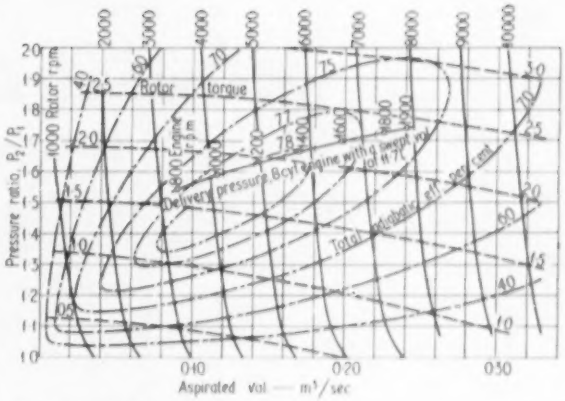
——The Saurer AG3S blower
– – – –Roots type blower, D/L=130/240

Performance curves obtained by tests carried out with inlet pressure P_o=1 atmos. abs., and temperature t_o=20 deg C. The swept volume of both blowers is approximately 3.5 litres/rev

are good. Even at the lowest engine speed, a charge pressure of 0·5 to 0·6 atmospheric, gauge, is available; this, in conjunction with the good adiabatic efficiency, ensures that a high degree of supercharge is obtained.

These features have enabled extremely good results to be obtained, so far as vehicle performance is concerned. The power, torque and fuel consumption curves of the six-cylinder unit are plotted in an accompanying illustration, together with the data for the normally aspirated engine. By comparing the two sets of curves, it can be seen that considerable advantage has been gained by supercharging. The curves show that the fuel consumption of the supercharged unit is no more than 1 to 2 per cent greater than that of the normally aspirated engine, despite the fact that the blower is mechanically driven. The power output has been markedly improved, and the torque characteristics are favourable for road vehicles.

Results of comparative tests carried out with a Saurer blower of 3·56 litres displacement and a Roots type unit of approximately the same capacity are also shown in an accompanying illustration. From these curves, it can be seen that the adiabatic efficiency of the helical lobe blower, particularly at higher pressure ratios, is appreciably better than that of the Roots type. The noise levels are also shown in this illustration. Because the charge is compressed internally with the helical lobe blower, the Saurer unit operates more quietly than the Roots type, and can be run at substantially higher speeds without the noise becoming too great. This is an advantage for public service vehicles.



Good overall adiabatic efficiency is obtained over a wide operating range with the Saurer blower; the steepness of the pressure-volume curves indicates good volumetric efficiency

Rolls-Royce Silver Wraith Air Conditioning

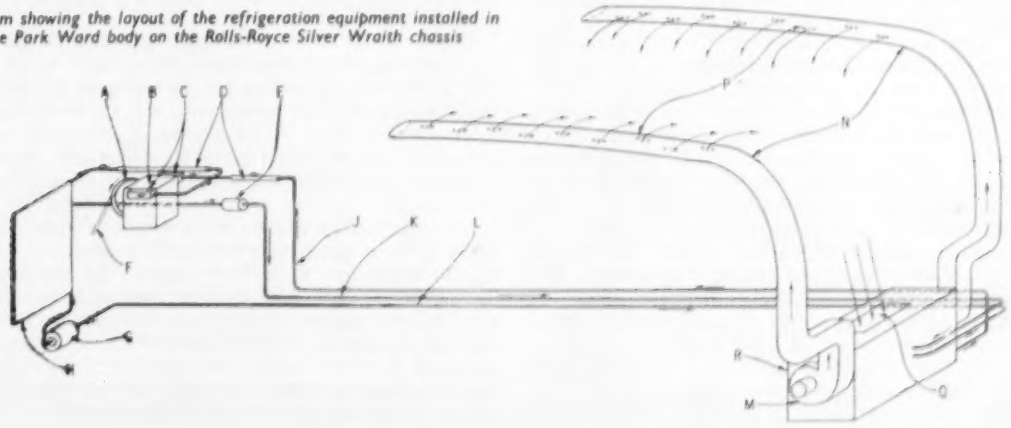
System Employed in the First British Passenger Car to have Refrigeration Equipment

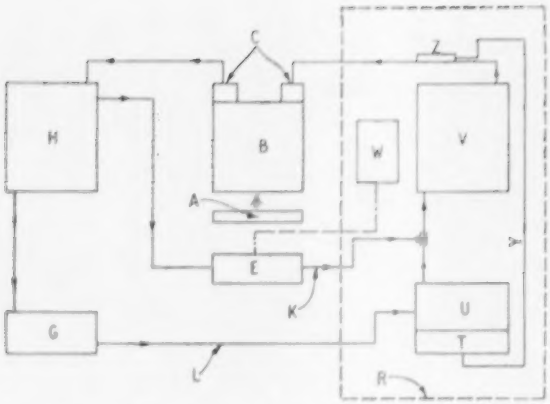
FOR obvious reasons, automobile air conditioning has been longer making its appearance in Britain than in the less temperate United States of America, and even now the system installed by Rolls-Royce is available only on cars intended for export. An example was exhibited at the Motor Show on a Park Ward bodied Silver Wraith. The humidity of the atmosphere within the car is not controlled, though this is inevitably affected by the cooling process. The system is, in fact, straightforward refrigeration and is entirely separate from any interior heating devices with which the vehicle may be equipped.

The task of cooling the interior air of a car does not sound prohibitively difficult. To begin with, there is a readily assessed relationship between the ambient temperature and what is comfortable for the occupants, a relationship which is strongly influenced by the clothing worn. People dressed for ambient temperatures in the eighties, for instance, are unlikely to welcome anything as low as 63 degrees Fahrenheit, normally recommended for office interiors in temperate climates. Yet there are special circumstances, for example, when the car that has stood closed for a long period in hot sun, and so the interior temperature must be reduced as quickly as possible. Therefore, cooling capacity must be considerable.

A Magnetic clutch; **B** Two-cylinder compressor on the right-hand side of the engine; **C** Charging valves; **D** Flexible pipes; **E** Solenoid Valve; **F** Belt-drive from engine; **G** Receiver and drier, mounted on frame; **H** Condenser, mounted between radiator matrix and shutters; **J** Suction line; **K** Control line; **L** Liquid line; **M** Two centrifugal blower units, one each side of the evaporator unit; **N** Distributor ducts built into the roof and thermally insulated from the outer skin; **P** Louvres on the underside of the ducts; **Q** Inlet at the centre of the parcels shelf.

Diagram showing the layout of the refrigeration equipment installed in the Park Ward body on the Rolls-Royce Silver Wraith chassis





A Clutch; B Compressor; C Charging valves; E Solenoid valve; G Receiver and drier; H Condenser; K Control line; L Liquid line; R Evaporator unit assembly; T Control diaphragm; U Expansion valve; V Evaporator; W Thermo-switch; Y Temperature control line; Z Phial

The circuit diagram of the refrigeration system

A car usually runs at an interior temperature that is about 10 degrees Fahrenheit higher than the ambient, and Rolls-Royce have found that to reduce this temperature to that of the ambient is usually sufficient for comfort. They suggest that about three minutes of fast idling with the cooling control at maximum will reduce the temperature of the standing car to a reasonable value.

Refrigeration is by the vapour compression system, the refrigerant being Freon 12, which is dichlorodifluoromethane (CCl_2F_2) and which is also known as Arcton 6. At 50 degrees Fahrenheit it has the following properties:

Absolute pressure	61·39 lb/in ²
Specific volume:	
Liquid	0·0118 ft³/lb.
Vapour	0·673 ft³/lb.
Heat content:	
Liquid	19·27 B.Th.U/lb.
Vapour	83·78 B.Th.U/lb.

It is non-toxic, and the fire and explosion risk is very slight; also it does not corrode any of the commonly used metals and is miscible with lubricating oil. On the other hand, it is a solvent of some organic substances, including natural rubber, and has a considerable leakage tendency.

The typical circuit, in which this refrigerant is used, essentially comprises a compressor, condenser and evaporator, and the installation problem is mainly that of finding sufficient space. In view of the longer experience that American manufacturers have had with air conditioning for cars, it is not surprising that Rolls-Royce are importing certain American units for their purpose, though the compressors are, in fact, bought in England.

This compressor, a two-cylinder piston-type unit mounted high on the right-hand side of the engine, is driven by a double V-belt from the crankshaft. It is engaged by a magnetic clutch at the will of the driver and its purpose is, of course, to raise the saturation temperature of the Freon vapour above that of the cooling medium for the condenser, which is air. The outlet pipe from the compressor to the condenser incorporates a length of flexible tubing to allow for engine movement, the condenser being mounted in front of the normal radiator matrix but behind the radiator shutters which are a well-known feature of Rolls-Royce cars.

The condenser consists of a single serpentine copper tube with aluminium fins pressed on, in good thermal contact and spaced about $\frac{1}{8}$ in apart. It is a few inches short of the top of the car's radiator matrix, but the obstruction of cooling air to the matrix is such that certain modifications have had to be made to overcome this. The fan has been provided with a cowl—mainly to cope with idling conditions—and the car's cooling system is now pressurized to raise the boiling point. These measures have resulted in a 12 per cent increase in cooling capacity.

There are two outlets for the liquid refrigerant from the condenser, one a control line from a point high up on the condenser, where it will receive only partially condensed vapour, and the other at the base, receiving liquid Freon. The liquid passes into the combined receiver and drier unit mounted on the frame that acts as a liquid Freon reservoir and also as an extractor of water vapour. From this unit a pipeline passes under the body to the evaporator, which is housed in the front of the luggage locker under the rear parcel shelf.

The control line also runs under the body straight to the evaporator, its only interruption being a solenoid valve controlled by a thermostatic switch incorporated in the

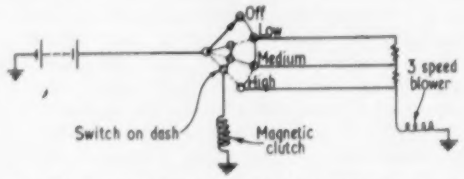


Diagram of the electrical control system for the refrigeration equipment

evaporator unit. This switch is in the outlet air stream to the car interior, so that when the temperature of the air stream falls below a certain value—about 50 degrees Fahrenheit—the solenoid valve is operated and permits partially condensed vapour to bypass the expansion valve and thus the cooling effect is reduced. The action is entirely automatic and its object is to prevent frosting-up.

The expansion valve, which is incorporated in the main liquid pipeline from the condenser, is diaphragm-controlled by a temperature line from a phial of vapour on the outlet, or suction, side of the evaporator, and maintains 9 degrees Fahrenheit of superheat in the vapour leaving the evaporator. This is to ensure that no liquid Freon returns to the compressor, where it would seriously reduce pumping capacity. The suction line, on its way back to the charging valve of the compressor, also passes under the body and incorporates a flexible portion to allow for engine movement. Thus the refrigerant circuit is completed.

Air is taken from the interior of the car through an inlet in the centre of the rear parcel shelf and also through small external intakes in the rear quarters; thus there is a limited injection of fresh air all the time. After being cooled, the air is extracted from the evaporator by two centrifugal blowers, one on each side, and expelled into the car through louvres formed in ducts built into the roof and thermally insulated from the outer skin.

Control is effected by a four-position switch on the dash. The positions are: off, low, medium and high. In the three "on" positions, a subsidiary contact energizes the magnetic clutch which starts the compressor; and the three stages of cooling are obtained by adjustment of the speeds of the centrifugal blowers within the air ducts from the evaporator. Maximum cooling can be obtained only at road speeds above 30 m.p.h.

The complete installation has a weight of about 280 lb., which so far as springing is concerned, is taken into account by the established Rolls-Royce practice of matching the suspension of individual cars to their bodywork. Only 5 or 6 b.h.p. is required to drive the compressor. In cars fitted with this equipment, the idling speed of the engine is slightly increased, both for cooling purposes and to eliminate any risk of stalling when the compressor drive is engaged while the car is stationary, for example, in heavy traffic.

Hydraulic Transmissions

(CONTINUED FROM PAGE 403)

PART II: *Discussion of Various Systems*

R. DEAN-AVERNS

POWER transmitting units making up the Cadillac Hydramatic drive are, in order: the flywheel cover; the front planetary unit, of single-reduction epicyclic gears; the fluid coupling; the rear planetary unit, this time with double-reduction epicyclic gears; and the reverse unit.

In the fluid coupling, the two rotor units, driving and driven members, are identical in profile, and have 48 vanes. These two members are fitted with only $\frac{1}{16}$ in clearance between them, and this, together with the fact that the torus is designed to provide a constant flow area, explains the comparatively high efficiency of this torus member itself, since the restriction to fluid flow is reduced to a minimum. Note has previously been taken of this feature of the fluid coupling, and reference to the description in Part I of this article will illustrate the principle as interpreted by Cadillac in their earlier designs.

Each planetary unit consists of three planet gears meshed between a sun and an internal gear, one of which is restrained from rotation by a band, which is released or applied by a servo mechanism in the form of a hydraulic-pressure-operated piston and cylinder. Also incorporated in each epicyclic unit is a multiple-disc clutch, which is released as the band on the gear is applied and *vice versa*. When the band is released and the clutch engaged, the whole assembly is locked and rotates as a unit. Conversely, in each unit when the band brake is applied and the clutch released, either the sun or the internal gear is held stationary. The planet gears revolve round the driving gear at a reduced velocity and, in consequence, the unit is in reduction.

Although, mechanically, the fluid coupling appears to be mounted forward of the two gear trains, its connection to each is such that it may be considered as located between front and rear sets, where its speed is reduced to 0·70 of engine speed, on account of the gear reduction in the front unit. Possibility of car creep when stationary with engine idling is therefore greatly minimized. This is not, however, the only advantage of such a disposition of the fluid flywheel. A feature of greater importance is the possible reduction of slip due to the fact that in third and fourth gears only 40 per cent of the torque is transmitted through the coupling, the remaining 60 per cent being transmitted mechanically. Fig. 20 shows the slip at all vehicle speeds in top gear and, as would be expected with such a layout, its value is very low at speeds above 35 m.p.h.

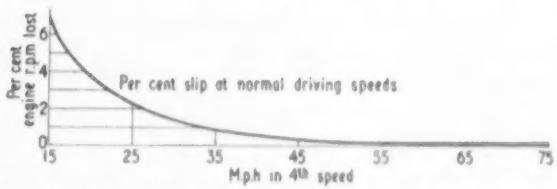


Fig. 20. Slip, at all vehicle speeds in top gear, of the hydraulic transmission of the Cadillac Hydramatic drive unit

The fluid circulating system is of interest. It consists of two independently-operating gear pumps, the front being engine-driven and rear driven by the transmission output shaft, Fig. 21. When the engine is started, the front pump builds up a pressure in the regulator valve housing and forces the valve from its seat. Fluid is then directed through

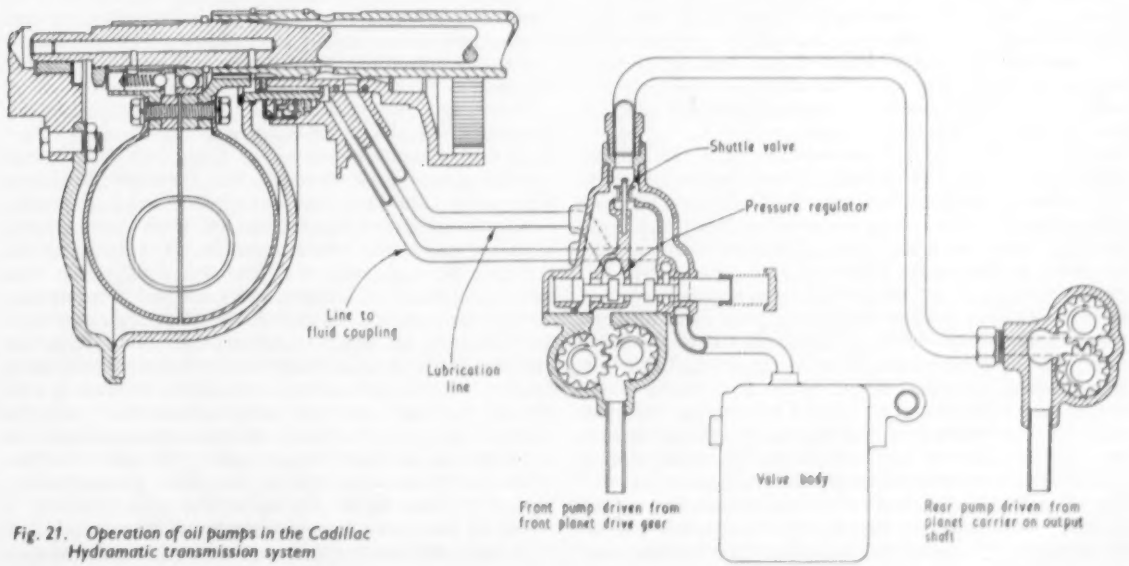
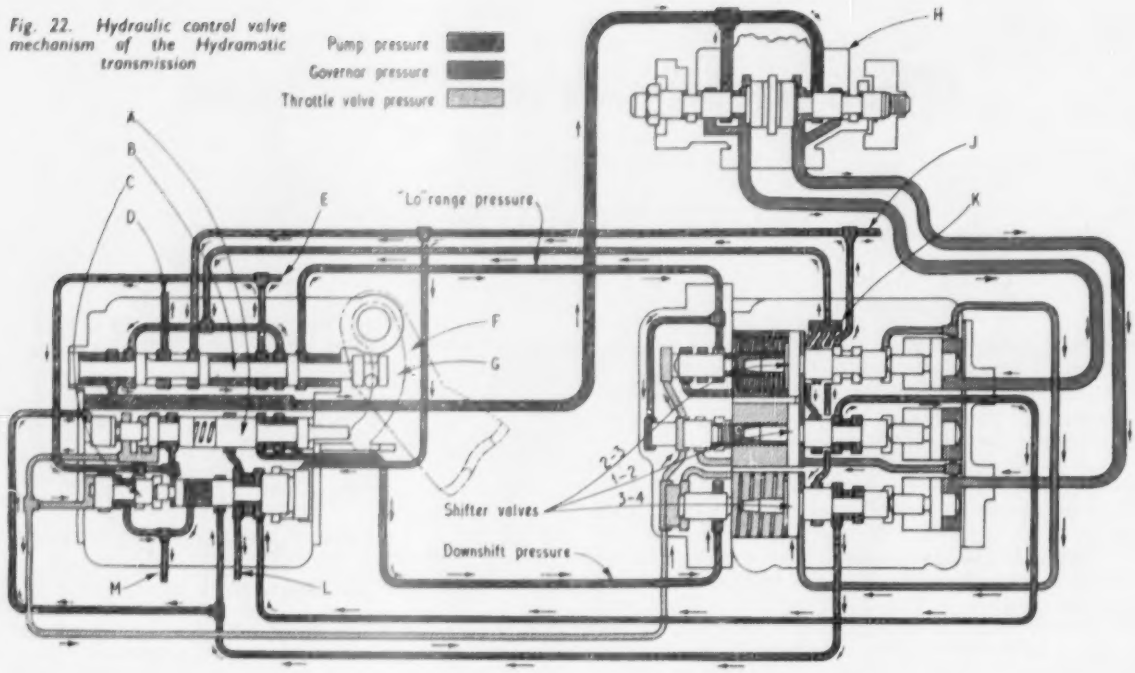

Shuttle valve
Pressure regulator
Line to fluid coupling
Lubrication line
Valve body
Front pump driven from front planet drive gear
Rear pump driven from planet carrier on output shaft

Fig. 21. Operation of oil pumps in the Cadillac Hydramatic transmission system

Fig. 22. Hydraulic control valve mechanism of the Hydramatic transmission



three channels; first, to the valve body for release of the rear unit brake band; secondly, at a predetermined pressure, to the fluid coupling; and thirdly, into the lubrication system. The regulator valve operates against spring pressure. As the fluid pressure increases, a spring-loaded shuttle valve seals off the fluid passage to the rear pump until that unit develops more pressure than the front. As the vehicle moves forward, this pump begins to develop a pressure opposed to the shuttle valve. When it reaches the predetermined pressure the valve opens, and thus pressure to the valve body is supplied by the rear pump. The front pump functions as a lubricating pump, supplying fluid to the coupling and the lubricating system. Positive lubrication is supplied to all components other than those lubricated by the oil in the fluid coupling.

Neutral and first speed. In neutral gear, there is no oil pressure to the front servo nor to either of the clutches. This is because the release spring in the front servo holds the front unit brake band in its "off" position. There is, however, oil pressure to the rear servo, which releases the rear unit brake band, so that with all bands and clutches free, no drive is taken through the transmission.

As the accelerator pedal is depressed and the vehicle begins to move, pressure is applied to the front servo, which in turn applies the front unit brake band. Oil pressure and spring pressure of the rear servo applies the rear brake band. Since the front band is applied, the front drum is held stationary, as also is the front sun gear. Rotation of the internal driving gear causes the front planet gears to revolve round the sun gear in the ratio of 1·44 : 1, or at approximately 0·7 times engine speed. Power is transferred to the front member of the fluid coupling from its rear torus. Since this front member is splined to the main drive shaft, which extends to the rear sun gears of the rear epicyclic unit, and due to the rear brake band locking the rear drum, the first rear internal gear is held stationary. In consequence, rotation of the first sun gear compels the first planet to revolve with the sun gear, but at a further reduction. The carrier for these planet gears is integral with the internal gear of the second rear planetary set. Rotation of this internal gear, at a speed lower than that of the second sun gear, causes the planet gears of the second epicyclic to rotate with a total reduction of 2·26 : 1 for the entire rear unit, giving an overall reduction of 3·26 : 1 for low speed. The carrier for the second rear planet gears is integral with the transmission output shaft.

Second speed. When the speed of the vehicle has increased sufficiently for the transmission to engage second gear, the brake band for the front unit is released by reversal of oil pressure to the front servo, and oil pressure is applied to engage the clutch in that unit. The rear unit is unchanged and, as in first speed, power flows to the internal gear of the front unit. However, the front clutch is engaged and so the front unit is locked. This causes the intermediate shaft to rotate at the same speed as the internal gear. The power then flows through the fluid coupling, back through the mainshaft and through the double-reduction unit at the rear to the transmission output shaft. Hence the total second speed reduction is the ratio of the rear unit which, of course, is 2·26:1.

Third speed. The front brake band is re-applied by the reversal of oil pressure to the front servo, while the pressure to the front clutch is cut off and so disengaged. Oil pressure to the rear servo is also reversed, but in this case it releases the rear band and the pressure is applied to engage the rear clutch. Power flow is thus through the front planetary unit, as in first speed, with 0·7 : 1 reduction. However, since the rear epicyclic unit is locked by the rear clutch, it not only rotates as a unit, but it has a direct mechanical connection through the intermediate shaft to the planet gear carrier of the front unit, the design of which is such that the power delivered to that unit is divided along the intermediate shaft. Approximately 60 per cent of the power is carried back through the locked rear unit and the remaining 40 per cent is carried forward, through the fluid coupling and back *via* the main drive shaft and the sun gears of the rear unit. The reduction, therefore, is that of the front planetary unit, plus 40 per cent of the slippage of the torus member. It should be noted that compensation for slippage is achieved by a slight rotation of the rear planetary gears, acting as a

differential gearing to combine these two power flows.

Fourth speed. When the change to fourth speed is made, both front and rear planetary units are locked. This gives direct drive. The front unit planet gear carrier, therefore, rotates at engine speed, its power being delivered to the intermediate shaft and divided in the same manner as for third speed, except that the output shaft receives a reduction in magnitude equal to that for the slight rotation of the rear unit.

Reverse speed. Two things occur when reverse is engaged. Firstly, a reverse anchor is moved into engagement with the external teeth of the reverse planetary unit. Secondly, the oil control valves are operated so that the band of the front unit is applied and the clutch released, while the brake band and clutch are both released in the rear unit. Therefore, the flow is as in first speed, and the rear sun gears rotate in the same direction as the engine. The internal gears of the rear unit are neither held stationary by the band, as in first or second speeds, nor are they locked by the clutch, as in third and fourth speeds. In consequence, they are free to rotate either with the sun gears or to reverse their direction of rotation and revolve backwards round the sun gear. The internal gear of the first rear unit rotates with the reverse unit sun gear, and the second rear unit planetary rotates with the reverse planetary unit. Meanwhile, the reverse internal gear is locked by the reverse anchor, which compels the reverse planetary unit to rotate backwards. In this way, the output shaft rotates in reverse at a reduction of 3·81 : 1.

Hydraulic control. This control system is basically a system of valves balanced to provide a precise relationship between vehicle velocity and desired performance. There are four main valves: a manual control valve operated by a lever on the steering column; a throttle valve, operated by the accelerator pedal; a governor valve, driven by the output shaft; and the compensator and change valve in the main valve body. The pressures regulated by these valves control the changes in speed of the transmission gears, Fig. 22.

Operation in neutral gear. When the car is stationary and the engine not running, the front band is released and the rear one applied, irrespective of the position of the control lever. The front band is released by oil pressure, and its position maintained by the assistance of a light retracting spring. The rear band is applied by both spring and oil pressure, but oil pressure only provides release.

High-range first speed. When the control lever is moved from neutral into the high position, the manual valve in the main valve body is repositioned so that oil pressure is built up and directed to the front servo, which in turn applies the front band. Oil pressure to the rear servo is shut off. The rear band is applied by spring pressure.

Both epicyclic units are therefore in reduction and both clutches are disengaged. Oil flows also to the governor, but since the vehicle is stationary and the drive to the governor is *via* the transmission output shaft, the governor valves are closed so there is no flow from the governor. These valves are opened as the speed of the transmission shaft increases when the vehicle moves away. The oil is admitted in such a manner as to build up a pressure in opposition to the centrifugal force applied to the valves. As the speed of the car varies, so output pressure from the governor varies between zero and 80 lb/in². To provide more flexible control, two valves with different pressure characteristics are employed. Governor pressure is applied to one side of each of these valves, opposing on the other side a fixed spring pressure together with a varying oil pressure controlled by the amount of accelerator pedal depression. The extent of this depression determines the throttle valve pressure, additional to the fixed spring-pressure, that must be overcome by the governor pressure to move the shift valve.

From first to second gear. As the car speed increases, the force exerted by the governor pressure on the valve controlling the shift from first to second speed exceeds the combined load of pressure and fixed spring load on its opposite face. Oil pressure from the pumps is directed to the front servo when this valve opens, and the front planetary brake band is released. The front clutch is also subjected to oil pressure from its controlling pistons and the gear changes from first to second speed.

From second to third speed. Further increase in car speed increases the governor pressure acting against shift valve 2 and 3, until it becomes sufficiently strong to overcome the spring and throttle pressure on the opposite side of the valve. In consequence, the valve opens, and pump pressure releases the rear brake band and applies the rear clutch unit. At the same time as the front unit brake band is reapplied, the rear clutch is released, and the shift from second to third speed then takes place.

From third to fourth gear. A similar operation takes place for this change, except that the governor pressure is directed towards shift valve 3 and 4, and also that the front unit brake band is released and the clutch applied. In this case, both front and rear planetary units are locked and the transmission is in direct drive.

Changing down to lower gears. When vehicle speed is decreasing, the governor pressure also decreases until it cannot overcome the spring pressure of the shifter valves; in this case the valves move back and a downward change is made.

From fourth to third speed. If this change is required for rapid acceleration, the accelerator pedal is depressed to its maximum, when the throttle valve opens a separate oil passage which directs oil at 80 lb/in² to shift valve 3 and 4, in opposition to the governor pressure. The transmission downshifts immediately.

Low range. Movement of the control lever to the low position applies additional oil pressure to regulator plug 1 and 2 and full pressure from the pump against shift valve 2 and 3. In consequence, the change from first to second gear takes place at a higher speed for a given throttle opening in low than in the high range. Governor pressure can never overcome the combined spring and oil pump pressure on shift valve 2 and 3, so that the transmission never shifts into third gear. Except for minor constructional details, this system is operative in its principle on the latest Cadillac models having Hydramatic control.

Chrysler electro-hydraulic control

Functioning in conjunction with a fluid coupling, the main gearbox has four forward speeds and built-in hydraulic and electric control. These four speeds are separated into two ranges of control, third and fourth in one and first and second in the other. A manual change is necessary to select the range, but automatic hydraulic control makes the necessary change up or down within the range. The coupling embodies accepted principles and the gearbox is straightforward in layout. The operating of the controls, therefore, is the main interest in this design.

A hydraulic cylinder and piston operates the gear change fork, hydraulic pressure of approximately 50 lb/in² being derived from a rotor type pump installed at the rear of the gearbox. The suction port is below the oil level and the pump is thus self-priming. Any drop of oil pressure would result in a down-change into the free-wheeling gear, hence the oil inlet position to the pump is in the middle of the transmission case. The rotor pump operates only when the vehicle is in motion, pumping oil directly to the relief valve. From here it is returned to the pump suction, except during the intervals when the hydraulic controls are making a gear change. Other parts of the control mechanism comprise the pilot valve, which is solenoid-operated; the main valve;

piston and engaging spring; and the kick-down, or return, spring.

The solenoid pushes the pilot valve on to its seating, and in this position the oil flow is sealed and returned through the relief valve. This is below governor speed; above this speed the governor points are opened, breaking the circuit to the solenoid so that the latter becomes de-energized. At this point, a small compression spring returns the pilot valve to the open position, when oil is free to circulate. From the pilot to the main valve the flow continues, the main valve controlling the oil flow to the cylinder behind the piston which operates the synchro-sleeve. The synchro coupling is controlled by the action of the two springs behind the piston. Starting in the very low speed range, the governor points open at approximately 6 m.p.h. Foot-pressure on the accelerator pedal is slightly eased to permit an automatic change into second speed. A manual change is made into the higher range to obtain third speed, and at a minimum speed of 14 m.p.h. the pedal is slightly eased to permit hydraulic change into top gear.

The relay has two sets of points, normally open, of which one set is for the solenoid circuit and the other for the interrupter switch circuit. Both sets are controlled by opening or closing of the governor points, depending upon the speed of the vehicle.

From first to second speed. In first speed with the engine running, a manual change moves the synchronizer sleeve into the low range, when the relay coil becomes energized, forcing the pilot valve to its seat and sealing the oil intake port. Above 6 m.p.h., in first speed, the governor points open, and the relay coil is de-energized, opening both relay points to break the solenoid circuit and de-energize the unit. The pilot valve is permitted to open, uncovering the intake port and allowing oil to pass to the housing below the main valve. The main valve also is moved to its open position. Thence the pressure operates the piston, which moves forward to a stop. The two springs (the engaging spring is the small, and the kick-down spring the large one) are compressed on the guide rail. The rail and fork move forward a short distance of $\frac{5}{16}$ in to the point of moving the synchro-mesh sleeve to a drive block position, the blocker ring now being in the blocked position. As soon as the accelerator is released and the engine permitted to synchronize with the car speed, the blocker ring is backed away and recesses into the synchro sleeve as the engaging spring moves that unit into engagement with the pinion for second speed.

From third to fourth speed. Exactly the same action takes place as in first to second speed, except that the governor points open at 14 m.p.h. due to the countershaft gear, which drives the governor, running at a lower speed in relation to propeller shaft speed than is the case in the low range.

From fourth to third speed. So long as the car speed remains in excess of 11 m.p.h. the synchro sleeve remains in fourth gear. As the speed is reduced, the governor points close, the relay coil is energized and both relay points close. The complete circuit is earthed and the solenoid energized, pushing the pilot valve down and releasing oil pressure behind the main valve. Spring pressure then moves the main valve downwards, freeing oil from behind the piston to flow back to the main case. The kick-down spring moves the piston back against the rail shoulder, during which movement of $\frac{3}{32}$ in, the ignition is interrupted by the closing of the points in the interrupter switch. This interruption releases the driving torque load and permits the synchro sleeve to be moved out of engagement with the pinion.

Leyland torque converter

A successful torque converter was fitted to a number of bus chassis within recent years by Leyland Motors Ltd. The unit was installed in a casing of similar appearance and dimensions to those of a standard type gearbox and clutch housing.

From the engine flywheel rearwards, the transmission consists of: a double-acting clutch, for connecting the engine to either the torque converter or direct to the rear axle; the hydraulic system of the converter; a free-wheel device; and reverse gear. Drive is taken through the free wheel only when the hydraulic unit is in use, its purpose being to protect the converter from over-run and to disconnect the turbine from the output shaft when in direct drive. With this arrangement, on starting the vehicle engine the clutch is engaged at idling speed. It is not required to slip, as is often the case. To produce acceleration the torque is built up by increasing revolutions of the converter, and the take-up is shockless when torque of sufficient value is attained. This torque is approximately proportional to the square of the speed. When the vehicle reaches a predetermined road speed of, say, 20 m.p.h., a toggle mechanism is brought into action and direct drive engaged. Torque converter drive can be engaged at any period without shock, and if required, the vehicle can be free-wheeled to its stopping point. Control is by the accelerator pedal, torque - speed changes being entirely automatic.

Oil discharges from the impeller in an outward stream, in such a way that at any axial section its flow forms an angle with the radial. On leaving the impeller vanes, the oil encounters the first stage turbine blades, which discharge into the fixed vanes of the first stage reaction member. An oil cooler is incorporated in a separate circuit, where the oil circulates through the natural pressure difference existing within the working circuit.

Hydraulic fluids

A few comments on important factors concerning fluids for use in hydraulic transmissions are of interest, as this matter is of considerable importance. To meet the requirements for such units, the fluid must possess high oxidation stability, ability to prevent corrosion, anti-foam properties, and satisfactory lubricating properties for mechanical parts.

Selection of an oil is usually based on its viscosity at working temperatures. During the operation of hydraulic equipment, the oil is subjected to conditions that tend to bring about oxidation, with its consequent deterioration. Oxidation is mainly due to heating whilst being agitated in the presence of air. These conditions are usually present as air cannot be entirely excluded from the system. Any parts made of copper are particularly liable to promote oxidation.

Different mineral oils vary considerably in their stability against oxidation, but nowadays various anti-oxidant additives assist in providing the required resistance. Such oils are known from experience to remain free from corrosive acidity for prolonged periods, although, irrespective of the condition of the oil, rusting is liable to occur. All mineral oils are capable of dissolving a certain amount of air, depending upon the temperature of the oil and its pressure. At normal temperature and pressure, the solubility of the air is in the order of 8-9 per cent, by volume.

During operations of the hydraulic system, the same air that was entrapped when the system was filled is alternately liberated from solution at low pressure and dissolved again at high pressure, so that the system must be well vented when oil is first introduced into it. The oil in the tank should also be devoid of anything likely to promote turbulence. This condition can be aggravated by unsuitable design of return oil pipes, which should always be carried to a point well below tank level. Air should be free to escape without hindrance and should not pass through the oil, as this is liable to cause frothing or foaming. Incorporation of foam suppressants in small quantities by the oil company enhances the anti-foam property of the fluid.

Requirements of the pump largely determine the viscosity

of the oil most suitable for use in an hydraulic system. In all fluid couplings and torque converters a large proportion of any power loss is due to the decrease in viscosity of the oil. In industrial traction couplings, temperatures are relatively low and thus low viscosity oils perform their duties of lubrication satisfactorily, but if the drive is transmitted at low speeds the heat produced is quite considerable.

Torque converters show quite wide variations in viscosity requirements, according to type. The Lysholm-Smith unit, for instance, requires comparatively light oils for the probable reason that this unit operates for long periods at high torque ratios, when excessive generation of heat would take place if the oil were of higher viscosity.

In this arrangement the hydraulic circulating system is efficient and ingenious. It comprises generally two independent gear pumps, one at the front being engine-driven, and the other, at the rear, driven from the transmission shaft. When the engine is started, the front pump comes into operation, building up a pressure in the regulator valve body. As this pressure increases, the valve is forced from its seat and oil directed through three channels. The first is to the valve body, for release of the brake band of the rear unit, and another is to the lubricating system of the fluid coupling. The regulator valve accomplishes all this, the valve moving against spring pressure as the fluid pressure increases. Meanwhile, a shuttle valve closes the port to the rear gear pump, and it remains closed until the rear pump generates a greater pressure than the front one, so that in neutral gear or at very low car speeds the front pump supplies all the pressure.

As the vehicle moves forward, the smaller rear pump operates, since it is transmission-driven, building up a pressure against the shuttle valve and when this reaches the predetermined amount, it opens the port so that the rear pump supplies all the pressure to the valve body. The function of the front pump becomes that of a low pressure lubricating pump for the fluid couplings and the lubricating system. The shuttle valve appears to be the predominating feature in the system, because when the first pump only is operating or when the transmission is in reverse, the valve prevents any fluid exhausting through the rear pump, since the port to that unit is closed

Converters and Couplings

A torque converter used in conjunction with a fluid coupling has advantages over the straight type converter. With a fluid coupling, input from the engine can only be equalled and not multiplied at output, whereas a converter provides, according to design, a degree of multiplication of input torque. A combination of both can provide a range of variable gears adjusting themselves from ratios of 1 : 1 of the torque input up to the maximum desired multiplication provided in the original design.

As has been explained, the difference, between a plain coupling and a converter lies in the fact that in the latter an additional set of blades is placed between the impeller and the turbine. This set provides the reaction member, and the blades are inclined at an angle to the axis of rotation: in the simple converter they are usually fixed to a frame and not permitted to rotate. However, in the converter-coupling, they are sometimes mounted on a one-way revolving clutch, but they are nevertheless locked to the frame of a container against opposite direction of rotation.

Main practical advantage of combining converter and coupling is found in industrial applications, but it resolves itself into a question of combined unit efficiency. The simple converter has an efficiency curve peaking at a maximum of approximately 60 per cent of its output speed, the curve falling again at maximum speed. However, with the combination, the curve rises rapidly and, as previously explained, it can be arranged so that it rises again instead of falling to zero when the coupling cuts in, with a 1 : 1 torque ratio of nearly 100 per cent efficiency throughout the remaining speed range up to maximum.

To fully comprehend this, it must be appreciated that blade profile becomes one of the major considerations in the design problem of the converter. The fluid coupling is somewhat simpler, but if the turbine blades are disposed against the direction of rotation, a higher torque can be absorbed by the turbine for the same volume of circulating oil.

It is known that the impeller and turbine possess equal and opposite relationships, so that any additional load imposed on the turbine is also imposed on the engine, *via* the impeller drive, tending to stall it. This is why there is little point in twisting the vanes, as under such conditions they do not assist in smoothing out the flow of oil, but merely lead to a condition of reduced efficiency.

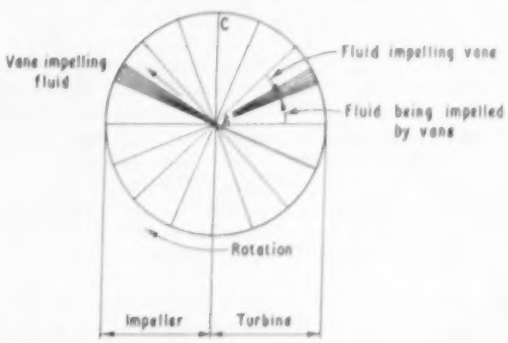
There are two methods of mounting the reaction member. In one it is fixed to a body frame, and in another it can be provided with a free-wheel mounting. Should the former scheme be adopted, there may be one point at which the engine input and output torques are equal, while at speeds in excess of this point the output is less than the input, providing a parallel condition with that of overdrive with the efficiency falling rapidly.

Mechanically, it is known that output torque is equal to input torque plus reaction torque, and thus the reaction torque must mathematically change its sign from positive to negative. However, if the reaction member is mounted on a free wheel, it can rotate freely under any additional torque in a direction necessary to increase the output, but it is allowed to rotate freely for speeds above the critical point. This critical point is called the coupling point.

It should now be clear that the volume of oil flowing at any period is identical for both impeller and turbine, and that the speed change should also be identical. This is the main reason why the coupling cannot multiply input torque.

If output load exceeds the input, the turbine will slow down, and with this slowing, slip naturally increases. This slip increases the pressure difference at points B and F, in Fig. 16a of Part 1 of this article. As the load continues to increase, the turbine eventually stalls, but the slip also has increased to such an extent to prevent the engine stalling with it. However, in the case of a converter when its turbine is considerably slowed, not only does this slow the impeller, but the impeller is also being driven, in addition to the engine drive, by oil from the reaction member. At this stage reaction blade design plays its part, as with the unit loaded to a low speed, the induced flow of fluid in the circuit is directed to form an impinging jet driving the impeller forward, so that the latter receives an amplified impulse, one from the

Fig. 23. So far as the fluid is concerned, the output torque of the hydraulic torque converter is dependent largely upon two features. These are: the volume of fluid circulating and the variation in linear speed of the fluid, in the direction of engine rotation, as it passes between the turbine and the impeller



engine and the other from fluid fromthe reaction blades.

Fluid passes from the centre to the periphery from A to C, Fig. 23. It will be clear that the circumferential speed at the centre will be much less in ft/min than it will be when it reaches C. For example, assume that the circumference of the inlet orifice is 2 ft at the centre, the circumference at outside diameter C is 6 ft, and engine speed is 1,000 r.p.m. Then the linear speed at A is 2,000 ft/min and at C, 6,000 ft/min.

The fluid has two motions; radially outwards, as shown by the arrow, and circumferentially with the vanes. On the turbine side it is the fluid pressure assisting the output torque, and as shown in previous text, the output torque is dependent to a degree upon two fluid features. These are the volume of fluid circulating and the variation in linear speed in the direction of engine rotation, in passing from the turbine to the impeller or *vice versa* to provide turbine torque.

Hydraulic clutch

Another mechanism, which owes its origin to the fluid flywheel is known as the hydraulic clutch. It has not been widely adopted, although it possesses features which are acceptable in an automobile transmission. These features include its capacity for taking up the drive either rapidly or progressively under full load, and also its pre-determined degree of slip, which can be fixed and maintained over long periods, without the generation of excessive heat.

However smooth the ordinary clutch pick-up may be, it is inevitable that a certain degree of uncontrolled slip will take place between the two plates revolving at different speeds. The amount varies according to the skill of the driver, particularly when breaking the clutch for a gear change. The effect of this slip is to increase the rate of liner wear, so that on a heavy clutch, servicing is generally required periodically between 30,000 and 60,000 miles. The Fraser hydraulic clutch was designed to control the amount of slip, while at the same time utilizing that property to advantage in obtaining controllable resilience throughout the full range of speeds, ability to control the amount of engine torque transmitted at all shaft speed variations and to permit the engine to maintain an efficient torque effort under load.

It will be appreciated that if this could be achieved, it might be possible to eliminate some of the gears in the transmission, while, in addition, it would not be necessary to race the engine when in the lower gears to effect a change into higher ratios.

Briefly, the mechanism functions as follows. The clutch comprises a member attached to the crankshaft flange, which replaces the flywheel, and an outer casing which, together with the cam ring, forms a completely enclosed chamber. Inside this chamber the driven member, in the form of a number of radial cylinders, enshrouds a similar number of pistons, which in turn are reciprocated by contact with slippers. These slippers are fitted to the piston ribs, and the cam ring is bolted between the inner and outer members. Coil springs under each piston control the position when the rotor is at rest. Between each cylinder head there is a communicating passage filled with fluid; this constitutes the pressure zone, which is replenished from the chamber surrounding the rotor. This chamber is also partially filled.

Reciprocation of a piston transfers oil from opposite cylinders across the central zone, the displacement of one being equalled by the capacity of the other. Control of this oil transfer is by means of a slide valve in the communicating chamber; the valve is operated in the normal manner by the clutch pedal. When the passage of oil is restricted by movement of the valve ports, Fig. 24, the piston cannot reciprocate, and the resultant pressure between the cam and the piston slippers causes the mechanism to rotate as a solid

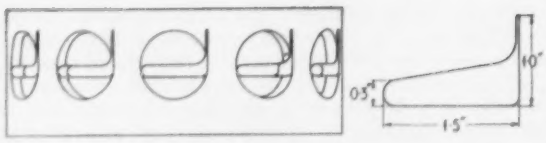


Fig. 24. Typical arrangement of oil ports in a valve sleeve

mass, in this way transmitting the full engine torque.

Action of the clutch may be either rapid or progressive, and the desired degree of slip can be maintained over considerable periods. Thus the engine can deal with heavy loads without the usual shudder upon starting, while with gentle clutch pedal pressure it can rapidly develop its power balance. The Fraser clutch was designed for a maximum fluid pressure of approximately 1,000 lb/in² in the high pressure zone in order to avoid any difficulties ensuing from erosion, while at such a pressure no trouble is experienced from compressibility of the working fluid in its de-aerated form. It should be noted that aeration of the fluid is desirable when the clutch is being engaged, in order to provide shock-absorbing properties, and on some of the earlier models vanes were constructed on the rotor to promote this feature.

Later experience, however, indicated that the irregular shape of the rotor aerated the oil to a sufficient degree whenever there was a difference in speed between the rotor and the outer member. When the valve is closed, this aeration quickly disappears, due to the centrifuging action. The de-aerated fluid then gathers near the periphery and is drawn through the suction-operated replenishment valves to replace the aerated oil as it escapes through the working clearance. Experiments have also proved that with normal working clearances and with a piston length equal to the diameter only, a slip of one per cent is obtained due to the amount of oil passing through these clearances at the pressures previously mentioned. These circumstances and pressures permit the total piston area required to transmit a given torque to be assessed, when the cam gradient is known. This is usually in the region of one in 15 to one in 20. The cam is symmetrical and is formed with two lobes of sine wave profile, and since an odd number of cylinders is employed, only one half the pistons are transmitting drive at any one time.

Thus, if there are 11 pistons with a two-lobe cam, the drive is sometimes on five and sometimes on six pistons. Total area of the five pistons would be designed to provide 1,000 lb/in² maximum oil pressure, which would mean that according to the cam gradient, the tangential force on these five pistons would be from 1/15 to 1/20 of the total radial thrust produced by the oil pressure. There are, of course, physical limitations that have to be considered, such as the number of cylinders that can be spaced round a given circle while still maintaining a reasonable cylinder wall thickness, a feature which may determine the control valve diameter. It is desirable to arrange that this valve possesses as small a diameter as possible, in order to maintain a reasonable proportion of length to diameter on the pistons. With the valve control almost closed, there was found to be a slight degree of automatic action due, in part, to the restriction on transfer of oil from cylinder to cylinder, which is a function of the ratio of speed of flow to the orifice area. This is desirable, since the connection between load and engine thus introduces certain flexibility in the transmission during driving in traffic.

The actual profile of the ports is very important, and in the case of an automobile clutch, it is desirable to form the port shape, or alternatively shape the valve, so that the first part of the valve closing movement seals off the major portion of the oil passage, the rate of closure diminishing as the fully closed position is reached. This is to eliminate the possibility of shock engagement, should the pedal be released abruptly.

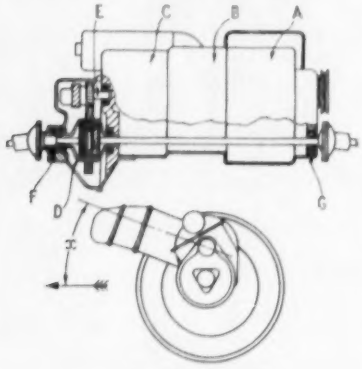
CURRENT PATENTS

A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

Front wheel drive propulsion unit

For a light, front-wheel driven vehicle with independent wheel suspension, a twin-cylinder engine, clutch, gearbox, and differential gear are combined in a transversely disposed, rigid assembly. The engine crankshaft is arranged above the axle shafts and the side-by-side cylinders are inclined forwardly to minimize height. A feature of the layout is that the differential gear is located at the end of the unit remote from the engine and thus the output shaft to the wheel adjacent to the engine is of sufficient length to provide the torsional flexibility which is normally lacking in compact propulsion units of this type.

In the illustrations, A, B and C indicate the engine, clutch, and gear units; the cylinder block projecting forward at an angle x not exceeding 30 deg from the horizontal. The differential unit D is gear driven at reduced speed from the gear shaft E and the short and the long axle shafts are supported at their extremities in



No. 748300

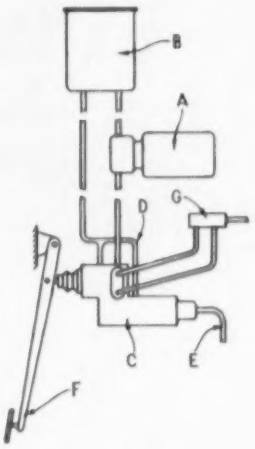
bearings F and G. Motion is transmitted to the road wheels by jack shafts and pairs of universal joints. *Patent No.* 748300. *Fiat Societa per Azioni (Italy).*

One-pedal control

The provision of an automatic transmission eliminates the clutch pedal and the gear lever. This invention reduces further the number of necessary controls by requiring only a single pedal to actuate both the brakes and the engine throttle.

An engine-driven pump A draws fluid from a tank B and delivers it under pressure to a servo unit C. A branch D of the return pipe to the tank supplies liquid for make-up of the hydraulic brake system when the piston of the master cylinder is fully retracted. From the master cylinder, pressure fluid is supplied to the brake cylinders by way of pipe E.

In its released position the control pedal F, which is normally held off by a spring, opens the inlet to the hydraulic cylinder and closes the return. Maximum pump pressure, determined by a spring-loaded relief valve, is thus maintained in the cylinder and the brakes are fully applied. Under this condition the pressure



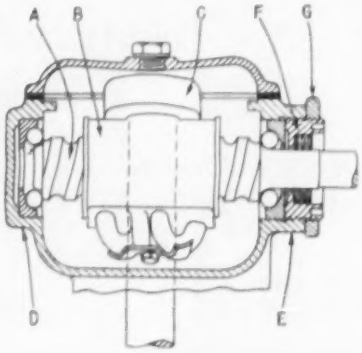
No. 748638

is equal at the two points, one on each side of the valve spool, at which fluid is tapped off to opposite ends of a slave cylinder G actuating the throttle. The throttle is then closed by a biasing spring.

To set the vehicle in motion the pedal is depressed to relieve the pressure in the master cylinder and consequently to release the brakes. Continued pedal movement opens fully the return from the cylinder and restricts the inlet, and a pressure differential is created between the tapping-off points. The piston of the slave cylinder is then unbalanced and the piston moves to open the throttle. At all times the position of the throttle is in direct relationship to the position of the pedal. *Patent No.* 748638. *Girling Ltd.*

Steering box

It is common for the steering gear to be enclosed in a multi-part housing with at least one bearing for the screw shaft supported in a cover. In this construction both the screw shaft and the steering lever are mounted in a one-piece housing which is closed by a single light cover. Screw shaft A actuates a recirculating ball nut B which is pivotally connected to the steering lever C.

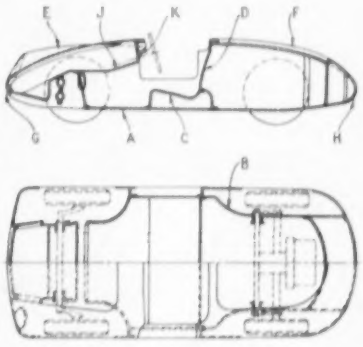


No. 747282

A pair of combined radial-thrust bearings support the shaft, the footstep bearing being located in a blind boss D. The other bearing is adjustably mounted in boss E and held up by screwed plug F carrying an oil seal ring engaging the steering shaft. Thus the preloading of the bearings can be finely adjusted to requirements and thereafter the plug F is secured in its adjusted position by means of lock ring G. *Patent No.* 747282. *Daimler-Benz A. G. (Germany).*

Synthetic material body

The construction proposed for this self-supporting body of synthetic material is claimed to reduce the costs and complications associated with bodies built of a large number of edge-reinforced mouldings, with smooth-surfaced mouldings having attached sheet-metal reinforcements, or with double-walled structures packed with



No. 747879

filler materials. A body for a rear-engined sports car is illustrated by way of example.

The main structural element comprises a bottom wall A connected to vertical side walls B and extending substantially for the entire length of the body. Centrally it is stiffened by a transverse member C which serves as a seat frame and a wall D which separates the rear engine component from the body interior. Parts C and D are anatomically shaped and provide seating accommodation merely by the addition of upholstery. To this structure is attached a front skin member E with lateral wheel-shrouding wings, a similar rear member F and nose and tail elements G and H.

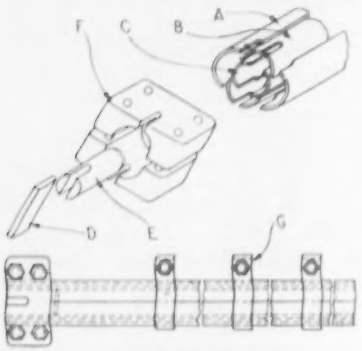
Luggage space at the front is provided by a trough-shaped member J which also forms the instrument panel K. Laterally, this member is fitted into depressions formed in the side walls B. Access lids are cut from skin members E and F after the mouldings are set, and the apertures are reinforced by Z-section moulded strips which serve as seatings for the lids. Door openings are also cut in the side walls. The constructional elements are joined adhesively, the bonding agent being preferably the same as the body material. *Patent No.* 747879. *F. Porsche (Germany).*

Tubular torsion bar

A solid torsion bar is relatively uneconomical in material since the central core of the rod contributes little to its torsional stiffness. The same consideration applies to a bar comprising an assembly of laminations of rectangular section. The solid bar also lacks the damping effect which is characteristic of the laminated bar. The laminated tubular bar of this invention avoids these short comings and its damping capability can be varied to suit specific applications.

A bar comprises three tubes A, B and C, each consisting of two semicircular sections, nested one within another. The abutting edges of the intermediate tube B are on a horizontal diametral plane and on tubes A and C on a vertical plane. At the anchorage end the tubes are slotted for engagement by a key D which is also received in the end plug E about which the tubes are clamped by the slotted end bracket F.

The assembly is maintained by three encircling clips G which impose damping in the bar by inducing friction between the tube surfaces. Damping effect may be varied by adjustment of the tightness and the positioning of the clips. Other methods of imposing damping may be utilized, either alternatively or additionally to the clips. The tubes, which may be either solid drawn or of complementary arcuate sections, may be so dimensioned in cross section that an initial damping is



No. 748587

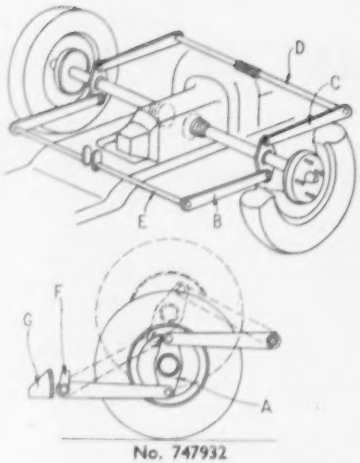
imposed on assembly. Axial or diametrical deformation of the innermost tube C could also be used to provide an initial damping effect.

Preferably the tubular elements of the proposed bar have their contacting faces treated to give a stressed-skin condition. Plug E and key D may be either formed integrally or permanently secured together. *Patent No.* 748587. *Austin Motor Co. Ltd.*

Independent rear suspension

Suspension of driven rear wheels by means of twistable lever arms connected to a transverse torsion bar gives a soft mounting that transmits little shock to the vehicle framing and occupies little space. Under certain conditions, it is stated, a skidding tendency becomes evident and thus it is undesirable for fast sports cars. To obviate this disadvantage each half-axle is furnished with a fixed, or pivoting, symmetrical link member A articulated with a forward lower lever arm B and a rearward upper lever arm C. Both lever arms are twistable.

The main torsion bar spring D is connected to arm C and an additional spring



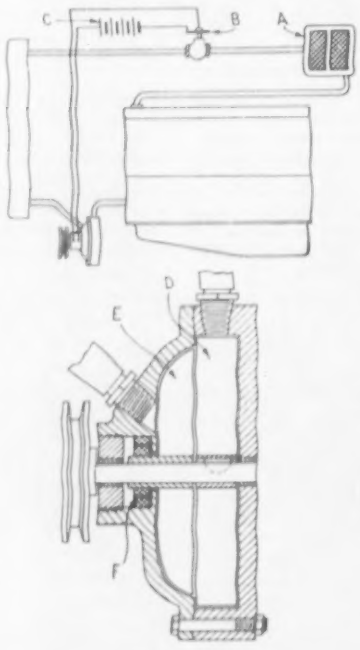
No. 747932

E connected to arm B becomes operative when the main spring is stressed to a predetermined extent. Adjustment is provided by lever F on spring E, which engages an abutment G. *Patent No.* 747932. *F. Porsche. (Germany).*

Combined circulating pump and heater

Intended to replace the conventional engine-driven water circulating pump, this unit also functions to provide heat to accelerate the warming-up process and to raise the water temperature to a value at which heat can be abstracted to warm the interior of the vehicle. Termed a "hydro-heater" pump, it is connected in series with an engine coolant system incorporating a heater A and its operation is controlled electrically by a thermally-responsive switch B and the vehicle battery C.

In the pump chamber is a vaned impeller D keyed to the shaft and, alongside, a



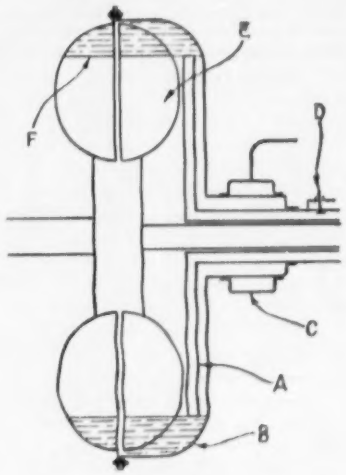
No. 749023

complementary vaned stator E which is freely rotatable on the shaft. For the control of the stator an electromagnetic brake F is provided; the inner element keyed to the hub of the stator and the outer element secured in the boss of the pump cover. In normal operation, when no heating is required, the stator is permitted to run freely and acquires the same speed as the impeller. When heat is required, the electromagnetic brake is energized and the stator is retarded and eventually arrested. The coolant is then heated as a result of turbulence and slippage between stator and impeller.

Automatic control is effected by switch B located, in the example shown, in the return pipe from the heater A to the radiator. Should it be desired primarily to control the engine temperature and to accelerate the engine warm-up, switch B would be located in the conduit between the engine and heater A. *Patent No.* 749023. *Thompson Products Inc. (U.S.A.).*

Controlled hydraulic coupling

Operation of this hydraulic coupling is controlled automatically in relation to the rotational speed of its output member;



No. 748146

that is, to the vehicle speed. At low vehicle speeds the coupling is partially emptied of fluid so that no drive is transmitted and when the engine is idling while the vehicle is at rest there is no residual torque to induce vehicle "creep."

The coupling embodies one or more stationary scoop tubes A extending radially outwards to the desired fluid level in the casing B. Fluid is supplied to the coupling by a pump, not shown in the diagram, which delivers to an inlet chamber C and thence passes to the casing. A valve D on the scoop-tube support is controlled hydraulically by a centrifugal governor in dependence on the speed of the impeller E, or the vehicle speed, to open when the speed of the impeller falls below a predetermined minimum. The coupling is then emptied by a return pump, not shown, to the level indicated at F.

The specification shows other arrangements to serve the same purpose; with rotating scoop tubes and also with a direct-acting valve mounted on the impeller at the fluid level and closed by centrifugal force. *Patent No.* 748146. *Daimler-Benz A.G. (Germany).*

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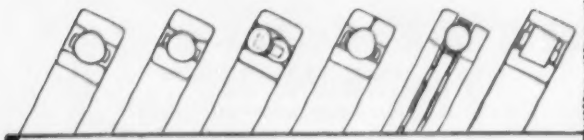

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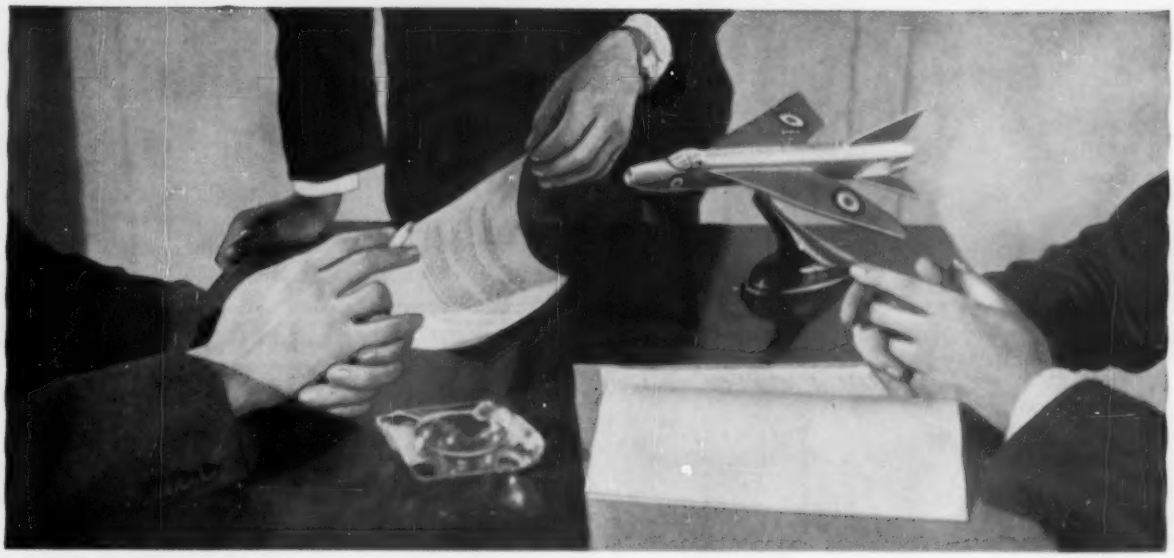

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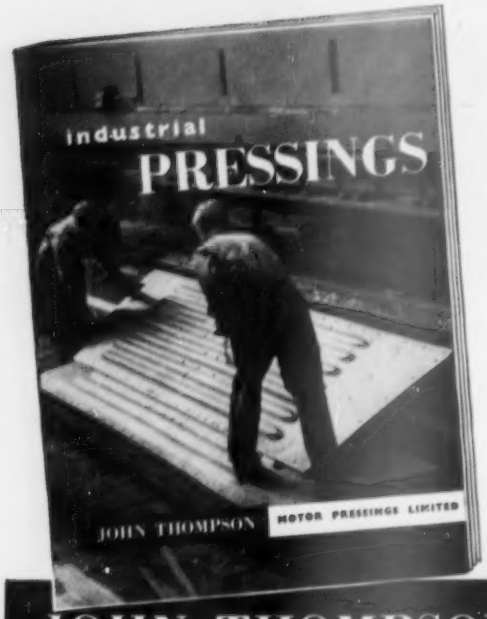

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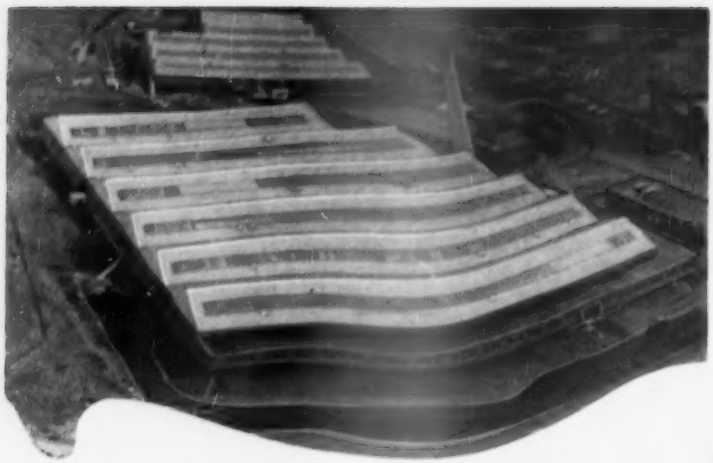

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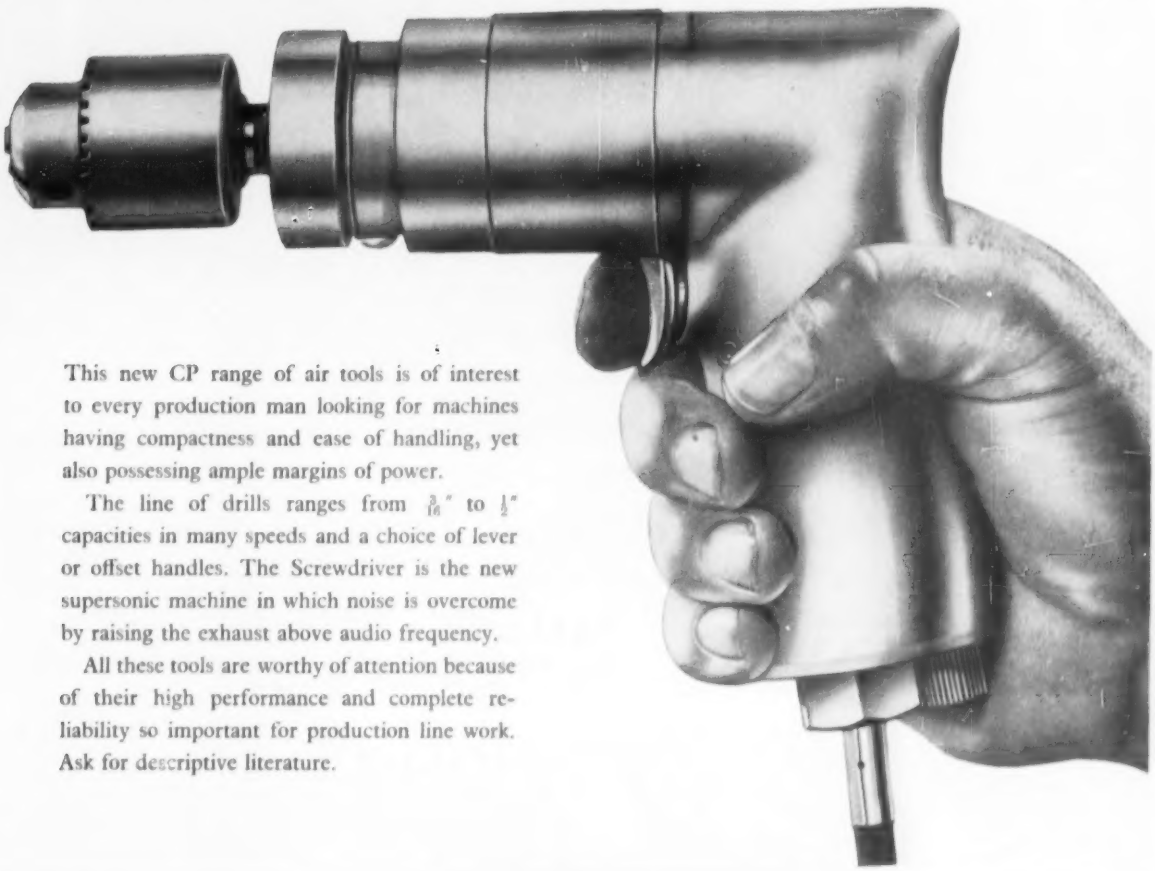

This new CP range of air tools is of interest to every production man looking for machines having compactness and ease of handling, yet also possessing ample margins of power.

The line of drills ranges from $\frac{3}{16}$" to $\frac{1}{2}$" capacities in many speeds and a choice of lever or offset handles. The Screwdriver is the new supersonic machine in which noise is overcome by raising the exhaust above audio frequency.

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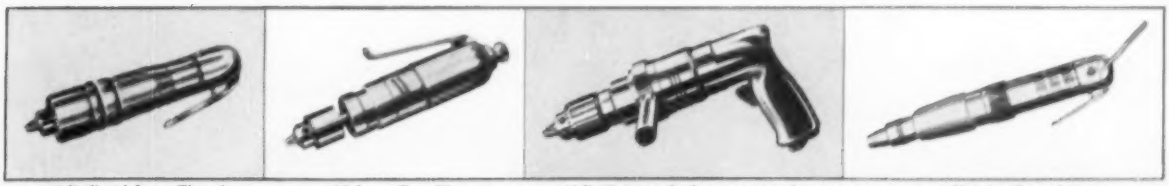

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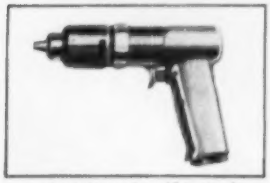

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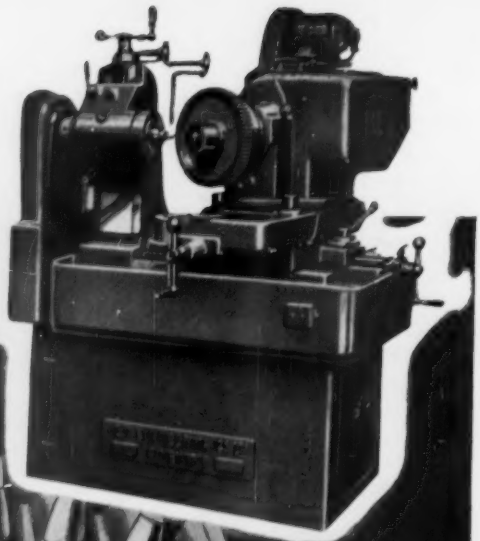

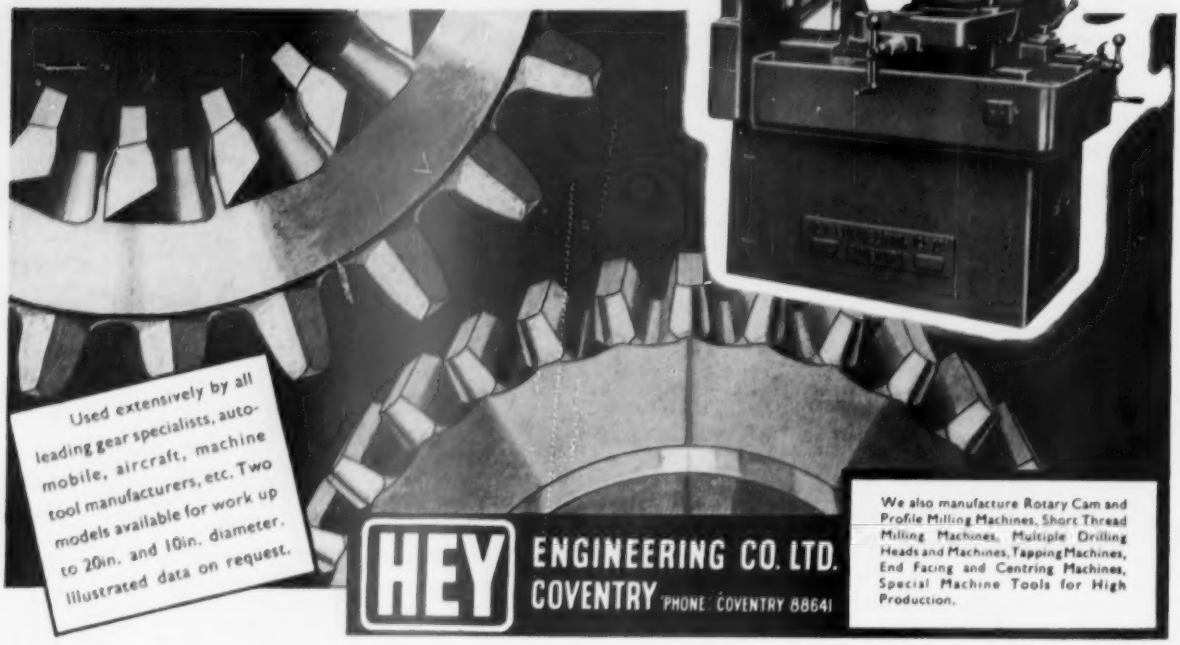

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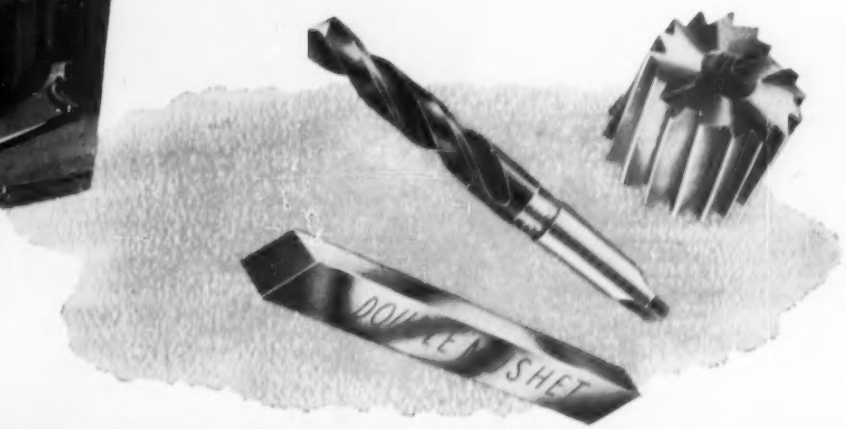

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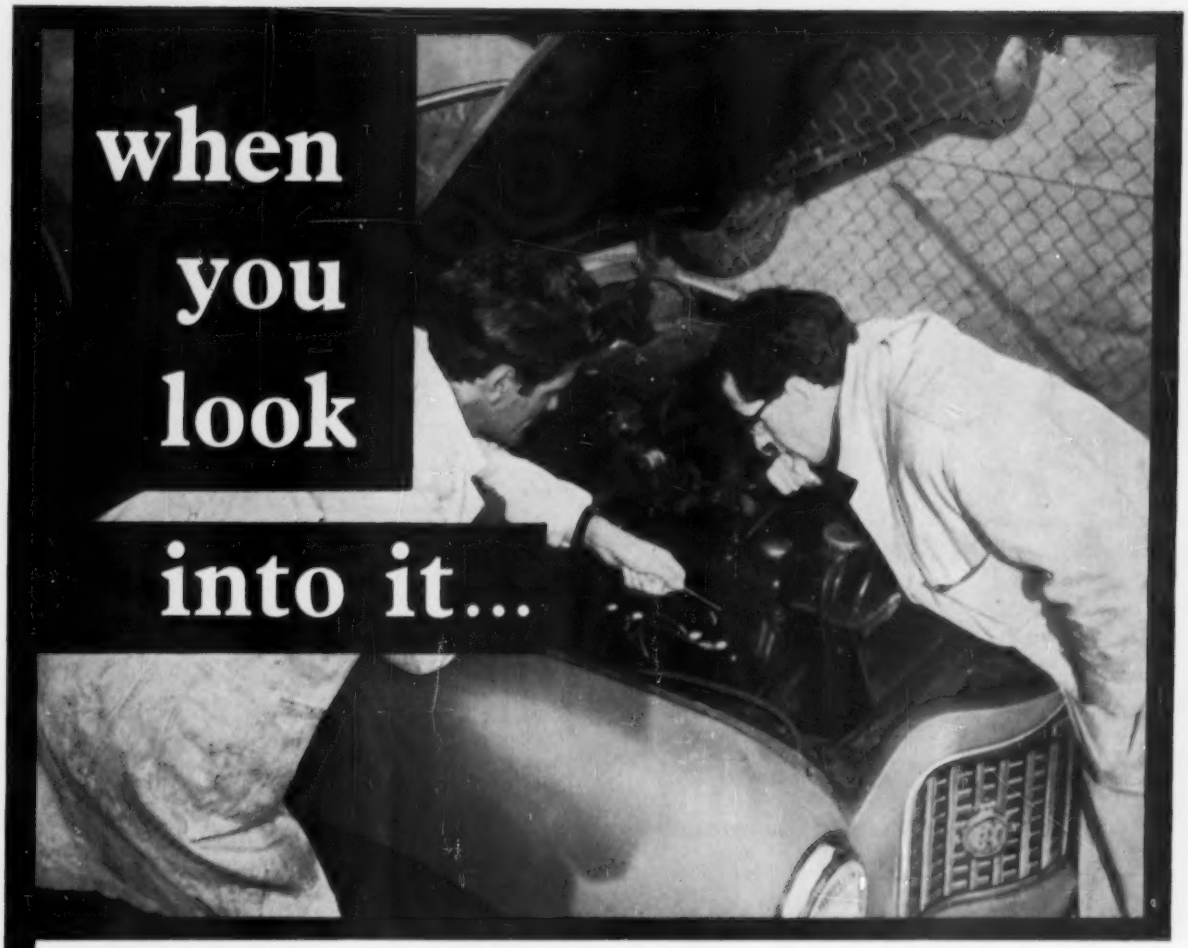

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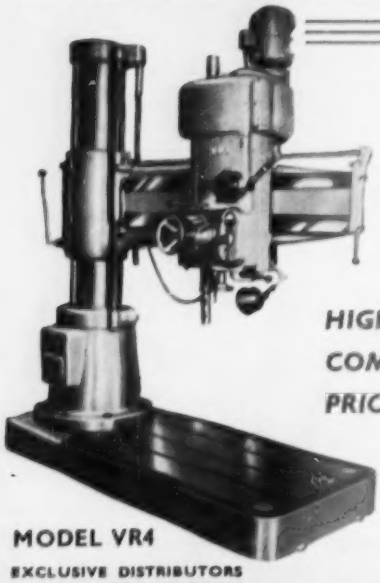

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Drilling Capacity in Cast Iron	1¾in.	2in.	3¾in.	4⅞in.
Max. distance centre line of spindle to column	31¼in.	49in.	79in.	99in.
Min. distance centre line of spindle to column	9in.	12⅞in.	17in.	19¼in.
Max. distance spindle nose to Box table ...	24in.	30in	52in.	64in.
Max. distance spindle nose to base	40in.	51in.	72in.	83in.
Vertical movement of arm on column ...	21in.	28in.	34in.	41½ in.
Taper in spindle	3 M.T.	4 M.T.	5 M.T.	6 M.T.
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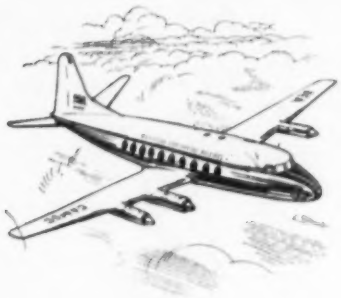

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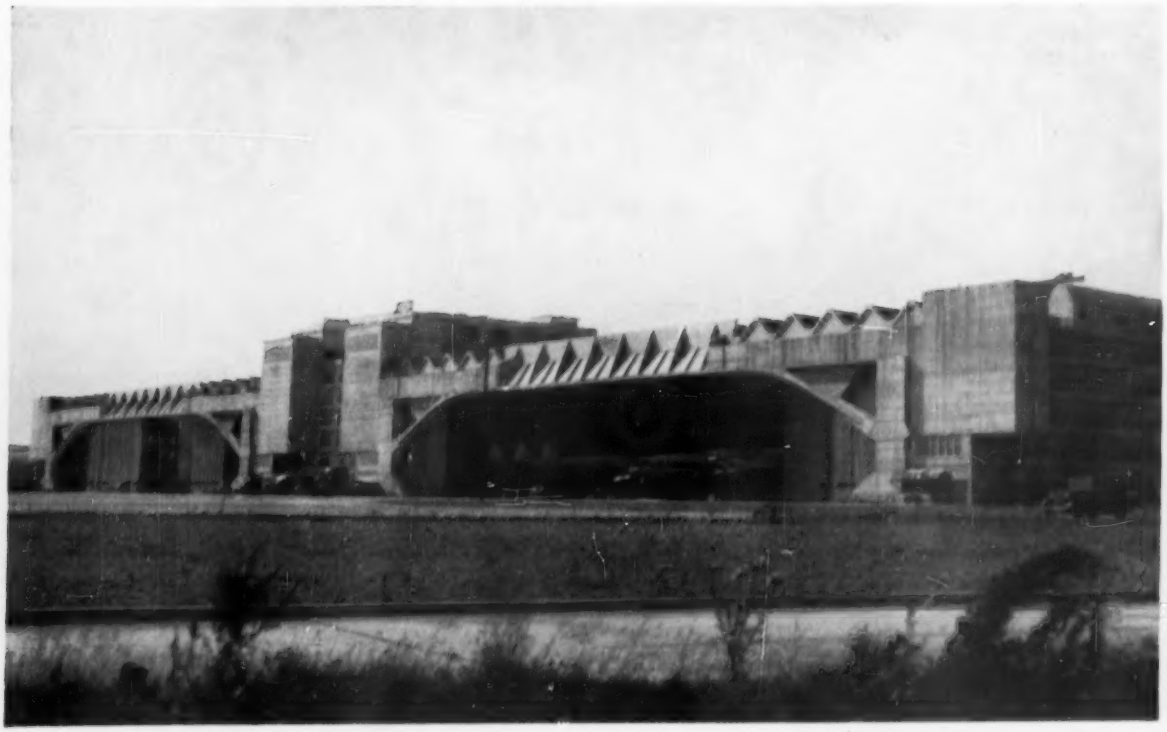

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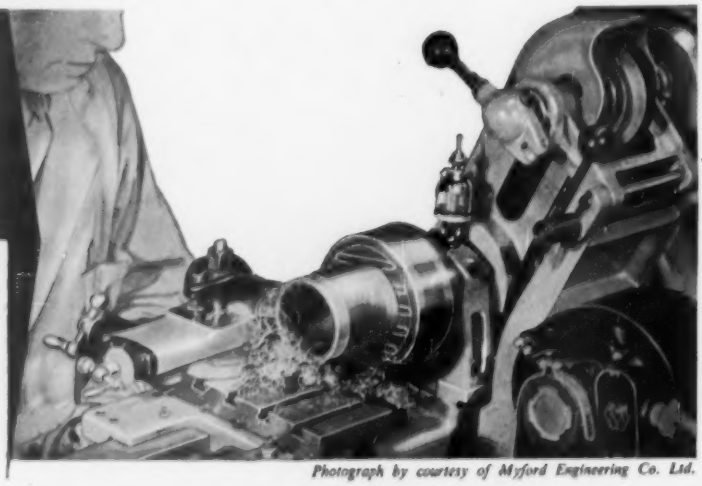

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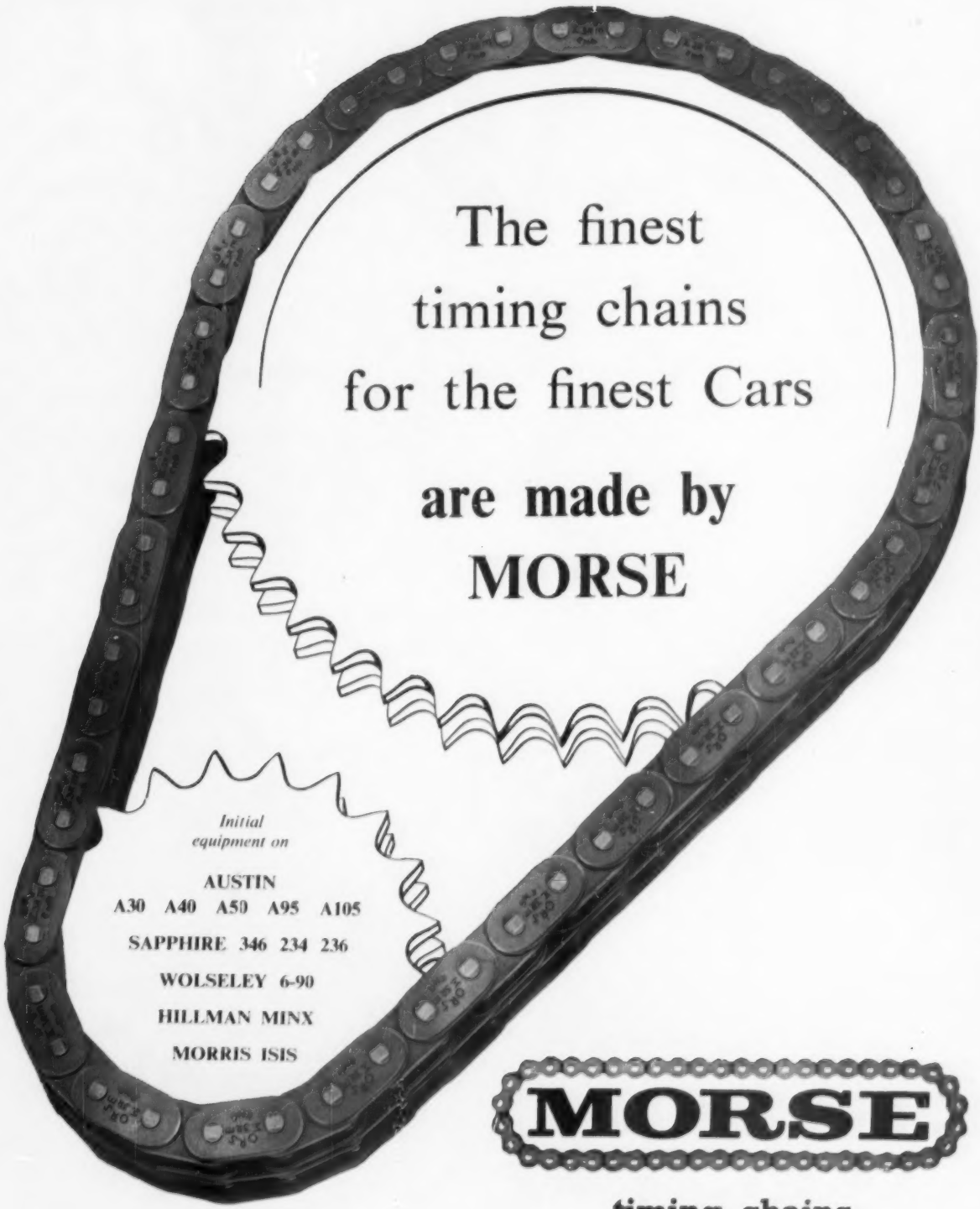

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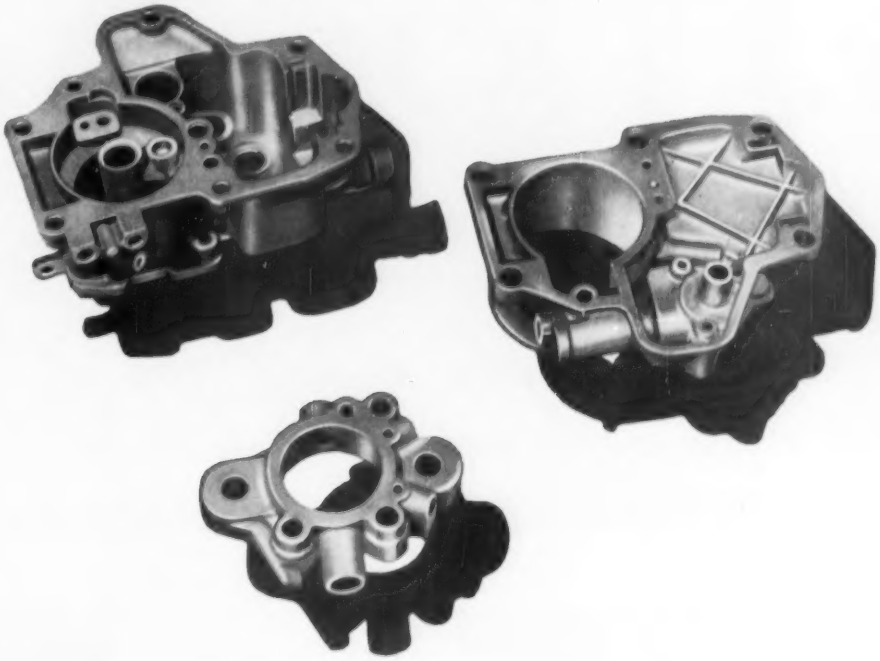

In these days of competition both at home and abroad, machining time is a vital factor in maintaining competitive prices. It is expensive in labour and materials, and accounts for a considerable proportion of overall production costs. One way of cutting it to a minimum, however, is zinc die casting. Consider carburettors, for example. These are one of the first component parts for which zinc alloy die castings were regularly used, and as their design has become more and more complicated, die castings have proved themselves to increasing advantage. No other process allows such fast production of accurately held, complex shapes. Cored holes need only reaming or, where necessary, tapping; and the free machining qualities of zinc alloys make such operations easy and fast. Mating surfaces can often be used as cast. Justifiably this process is claimed to be the shortest distance between raw material and finished product.

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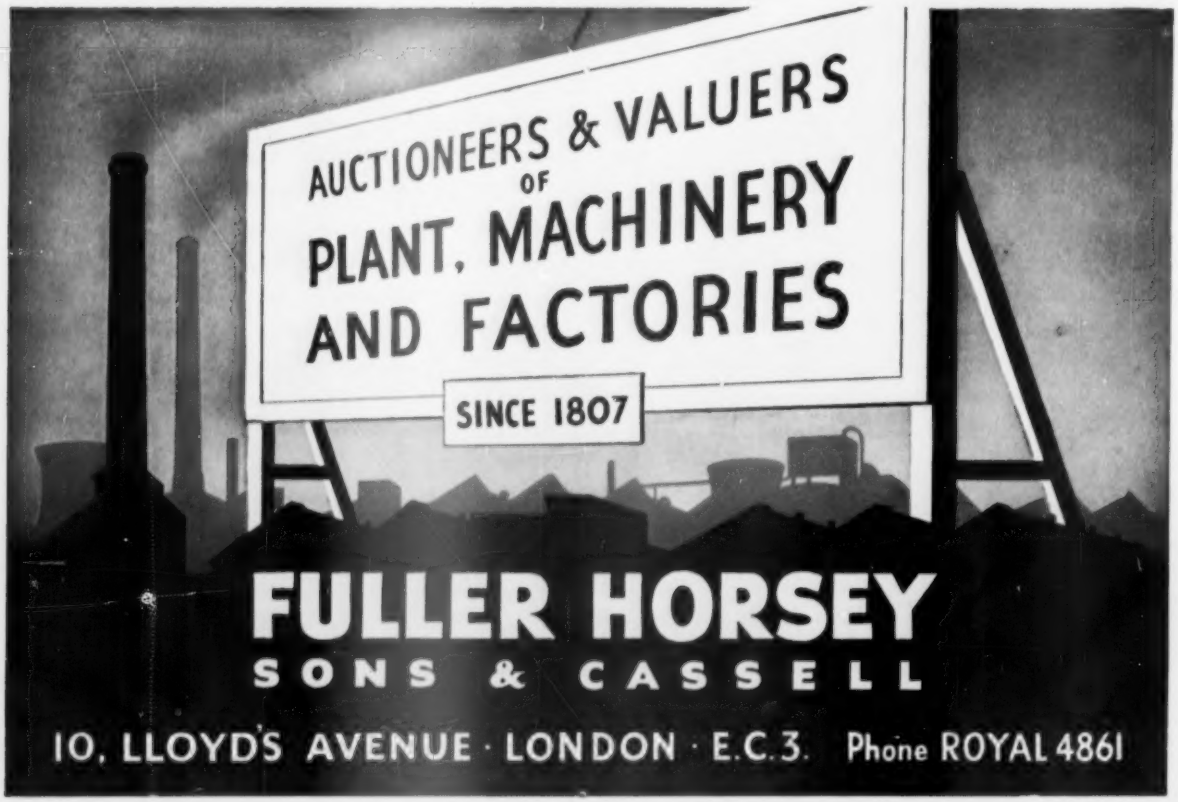

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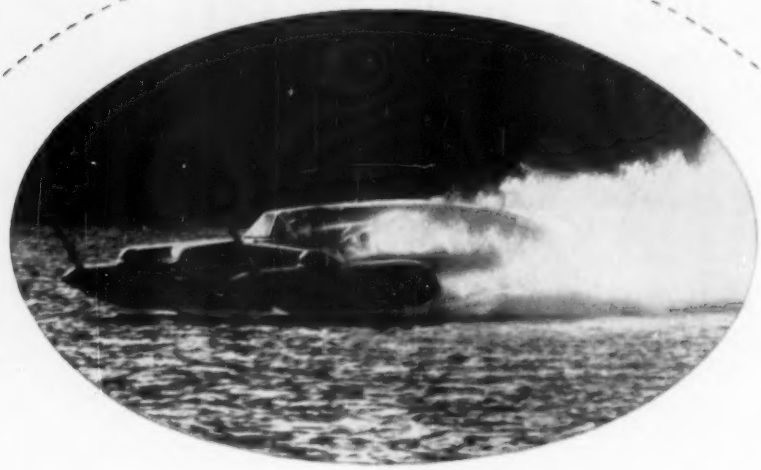

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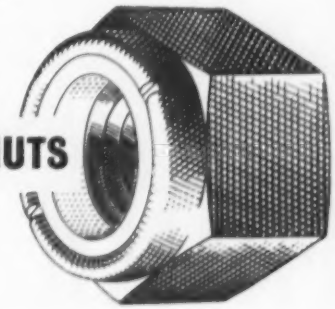

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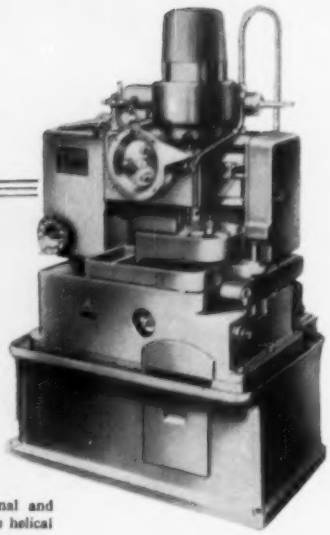

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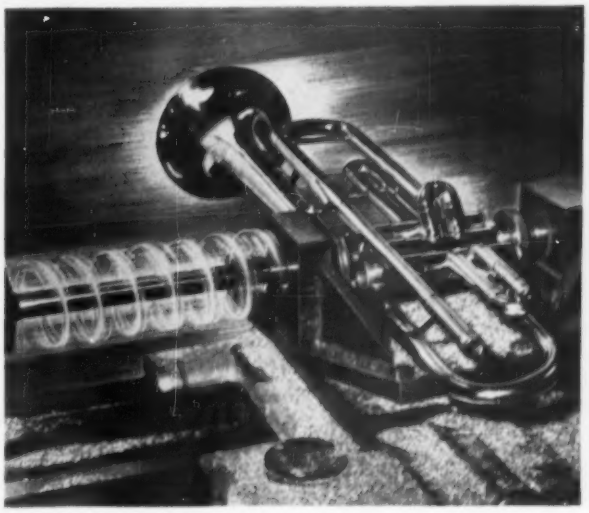

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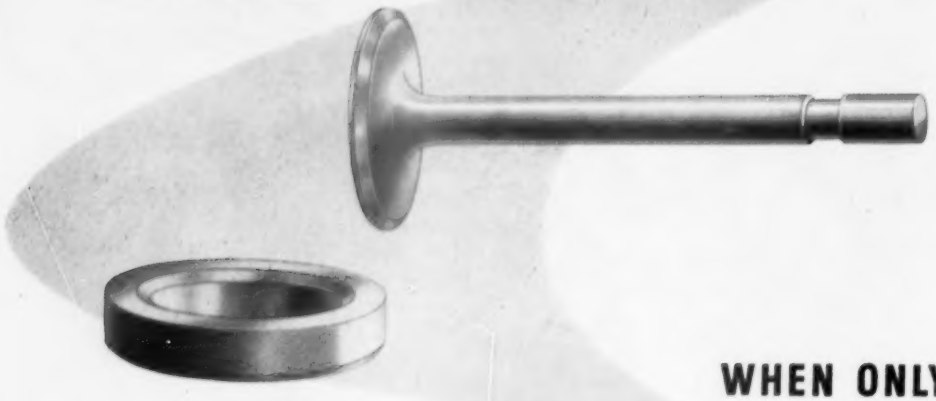

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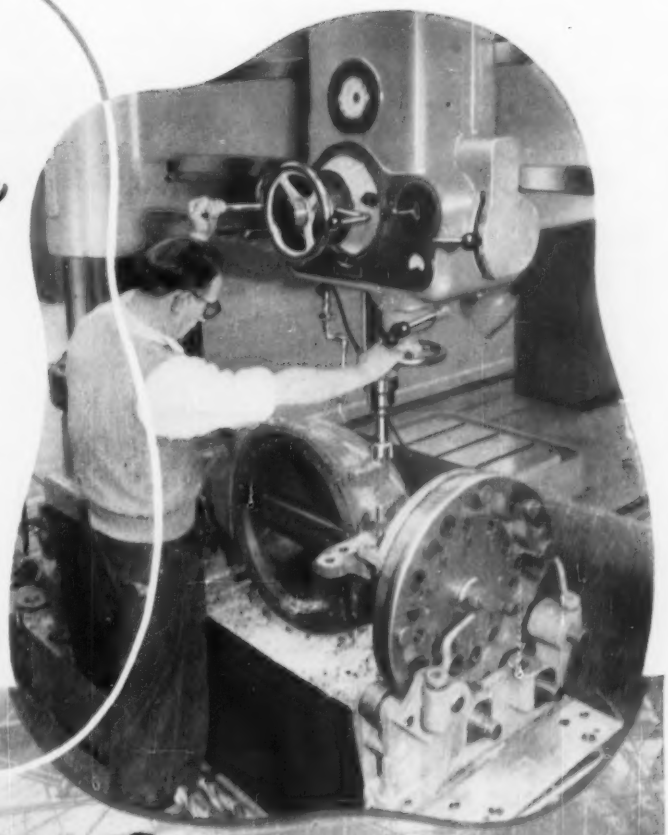

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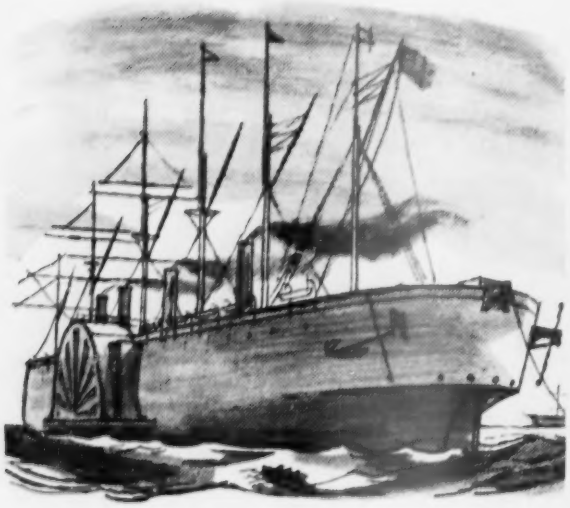

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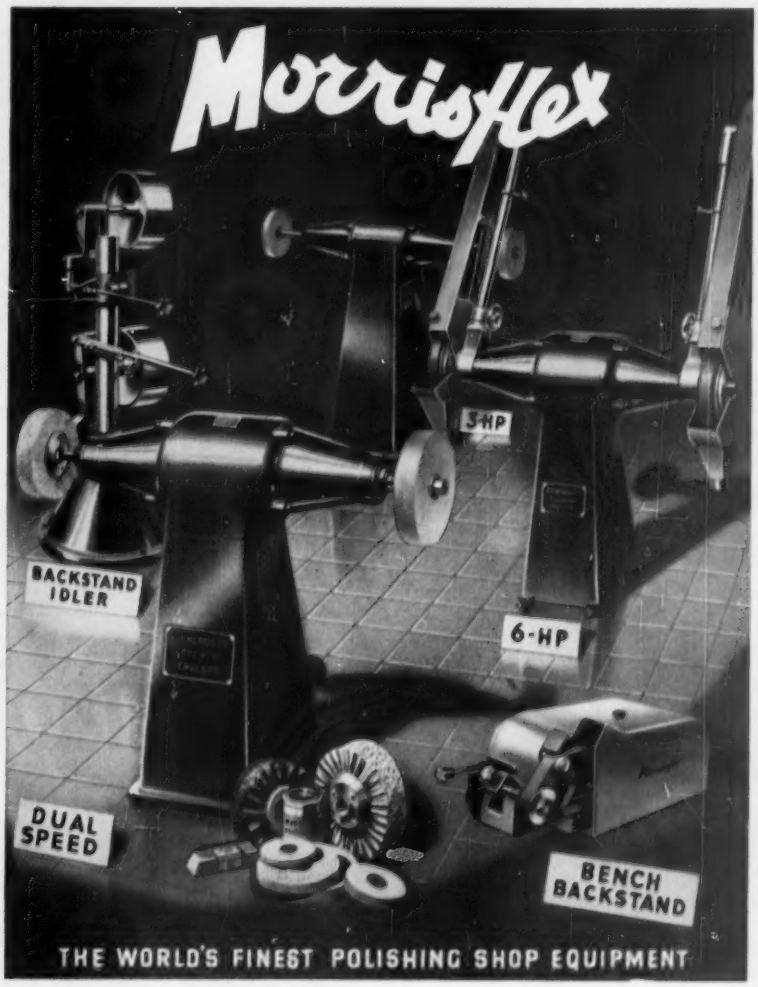

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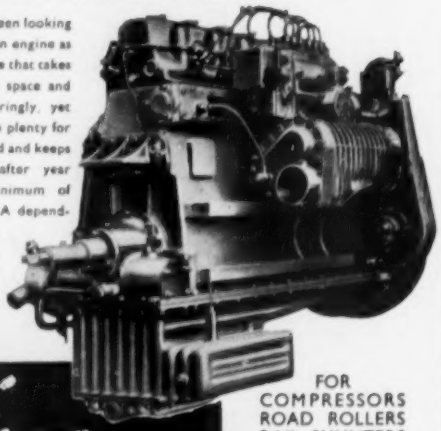

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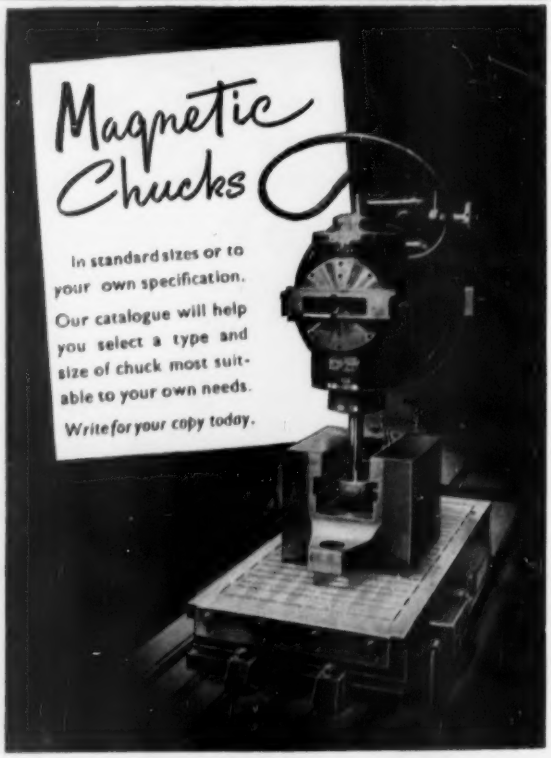
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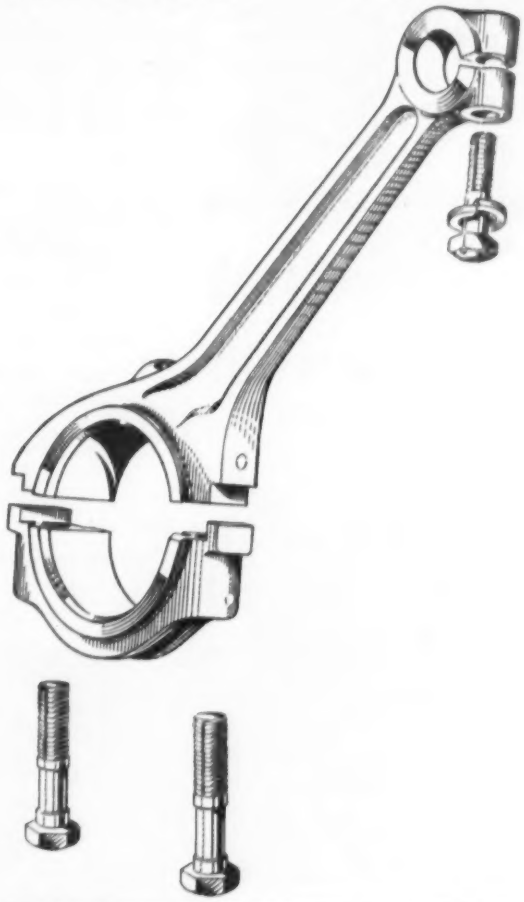

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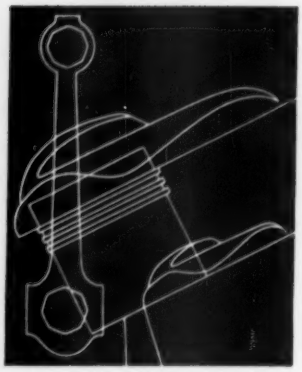

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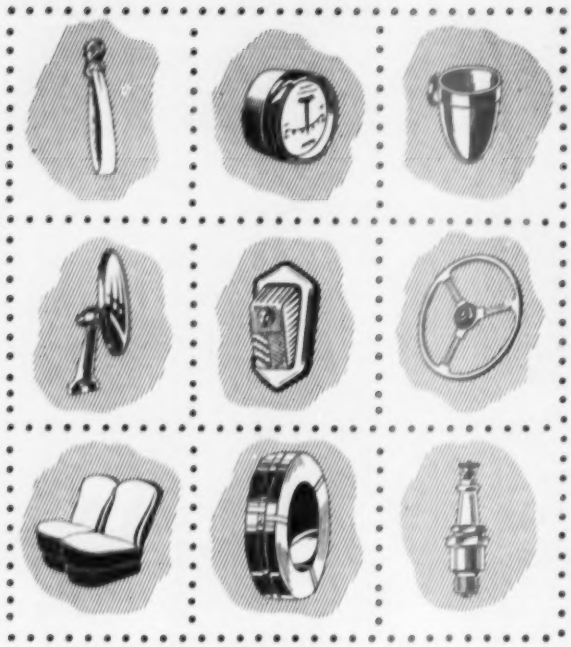

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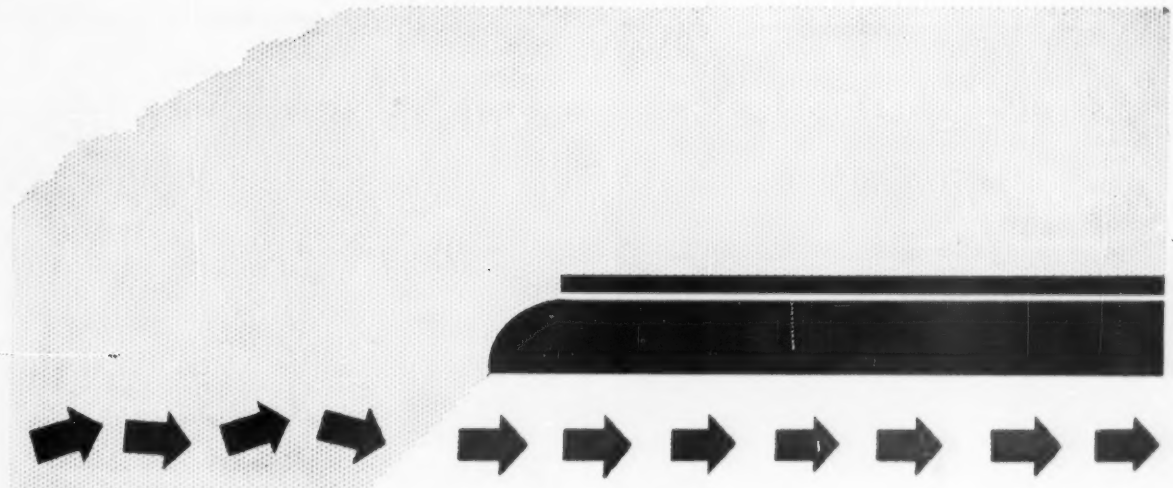

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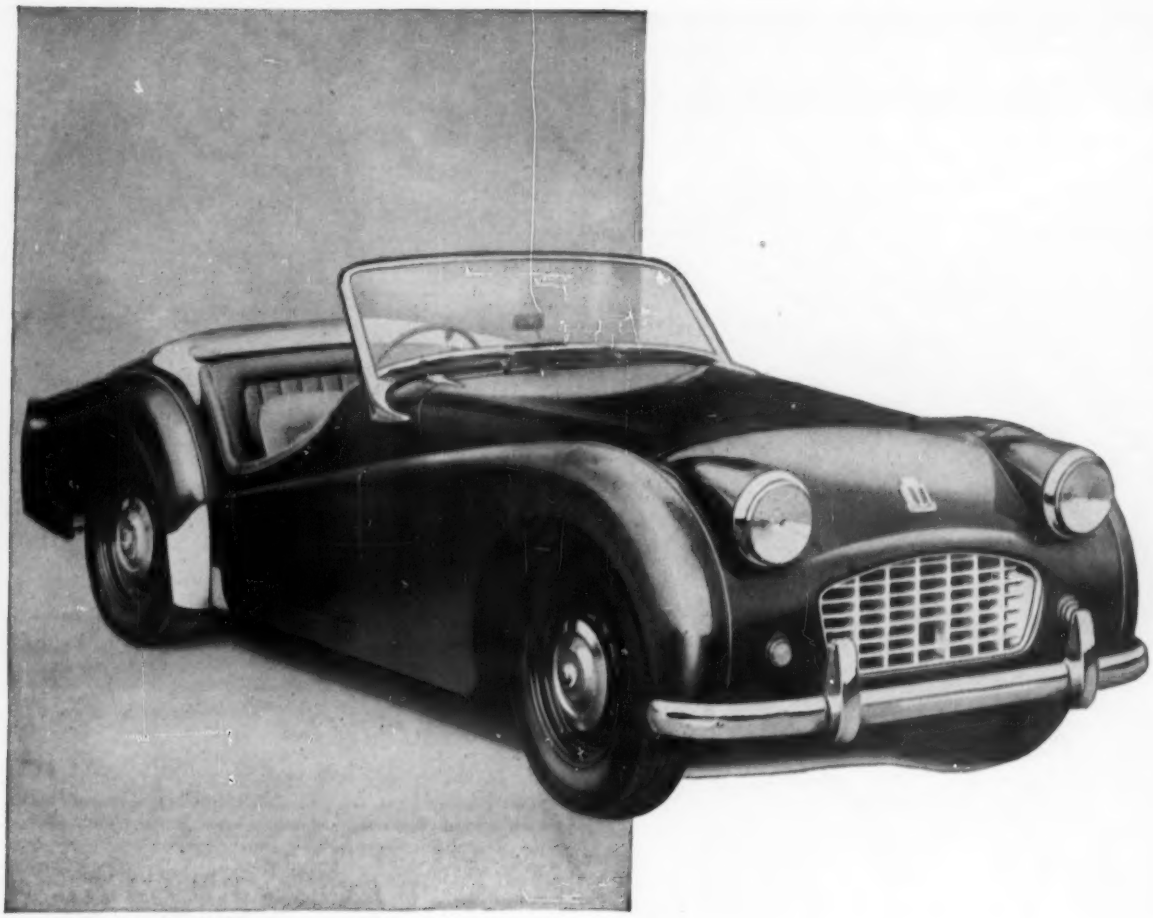

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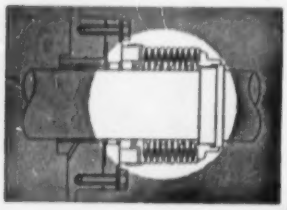

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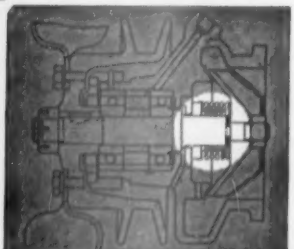

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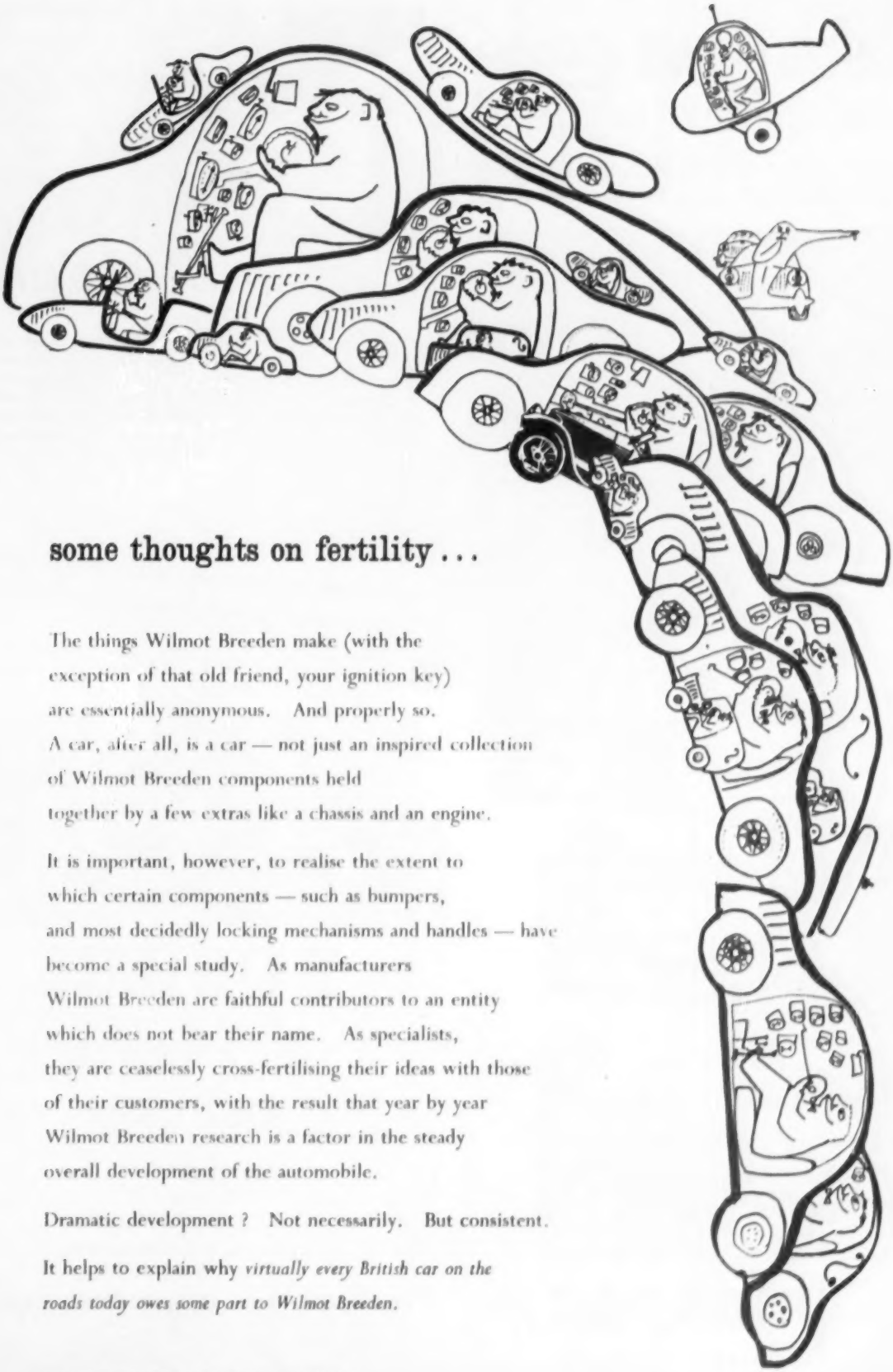

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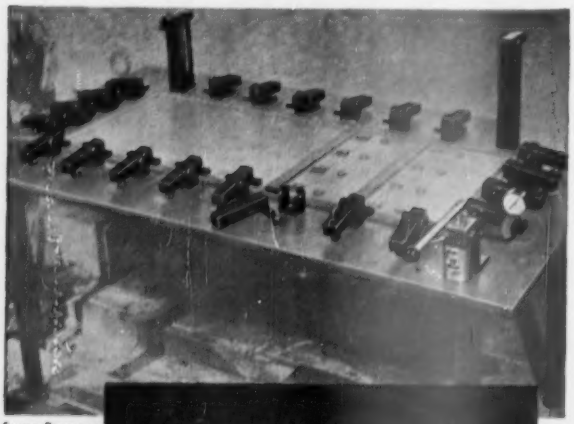

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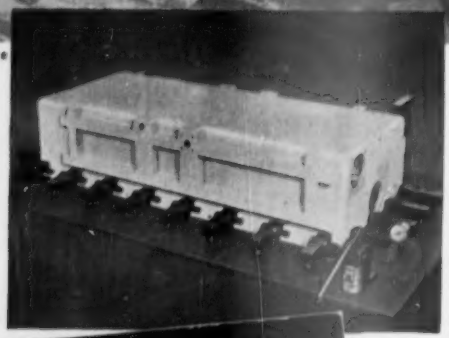

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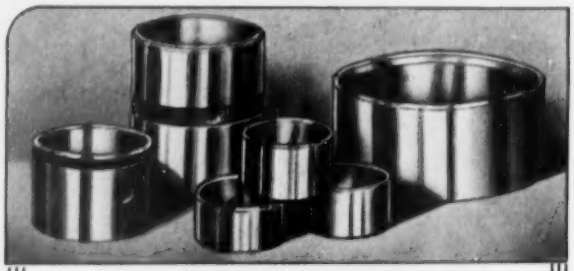

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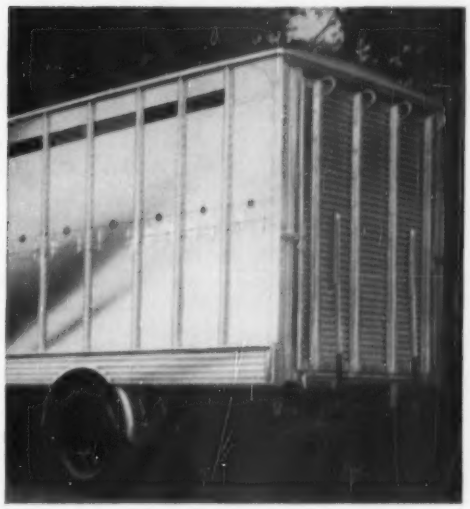

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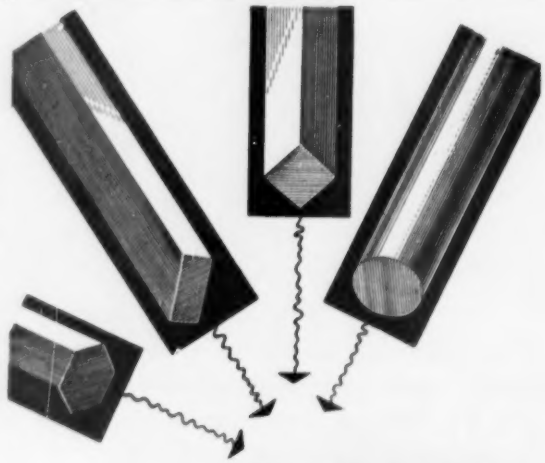

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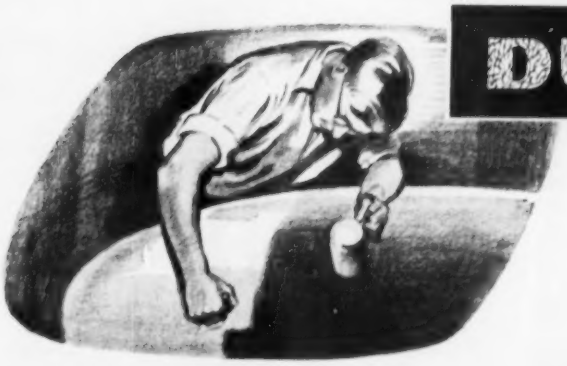

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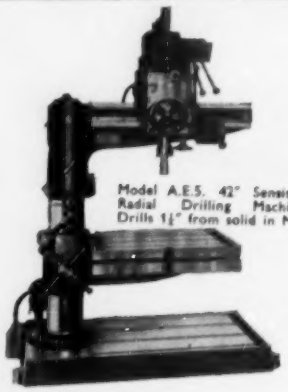

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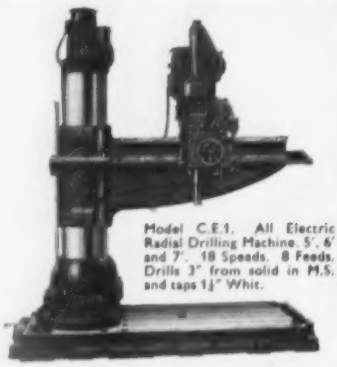

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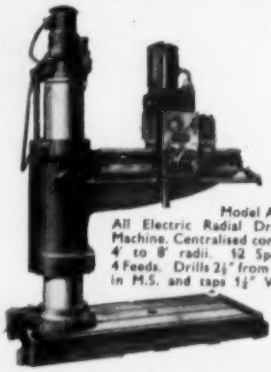

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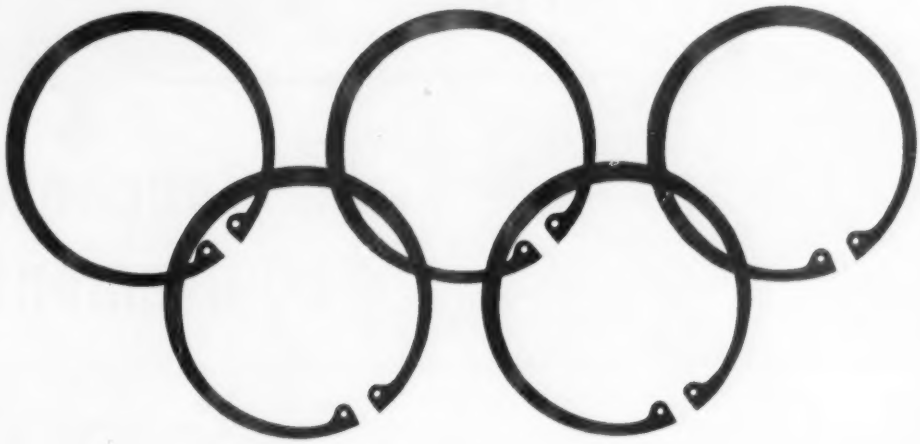

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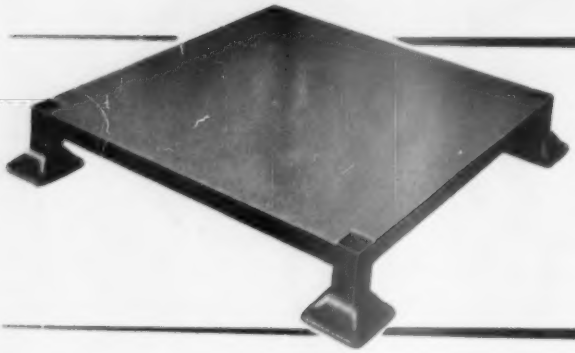

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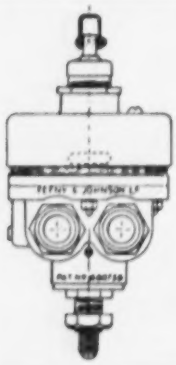

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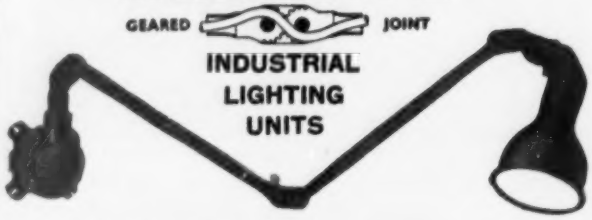

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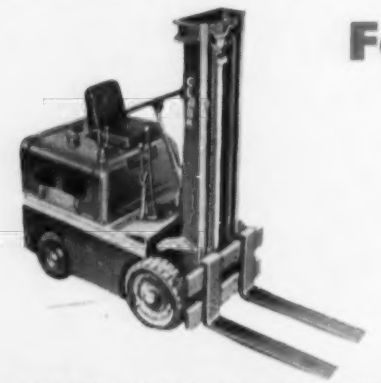

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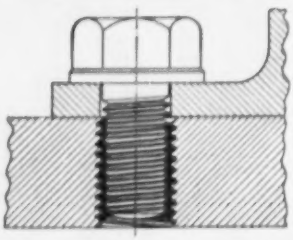

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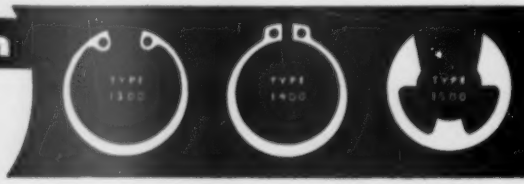

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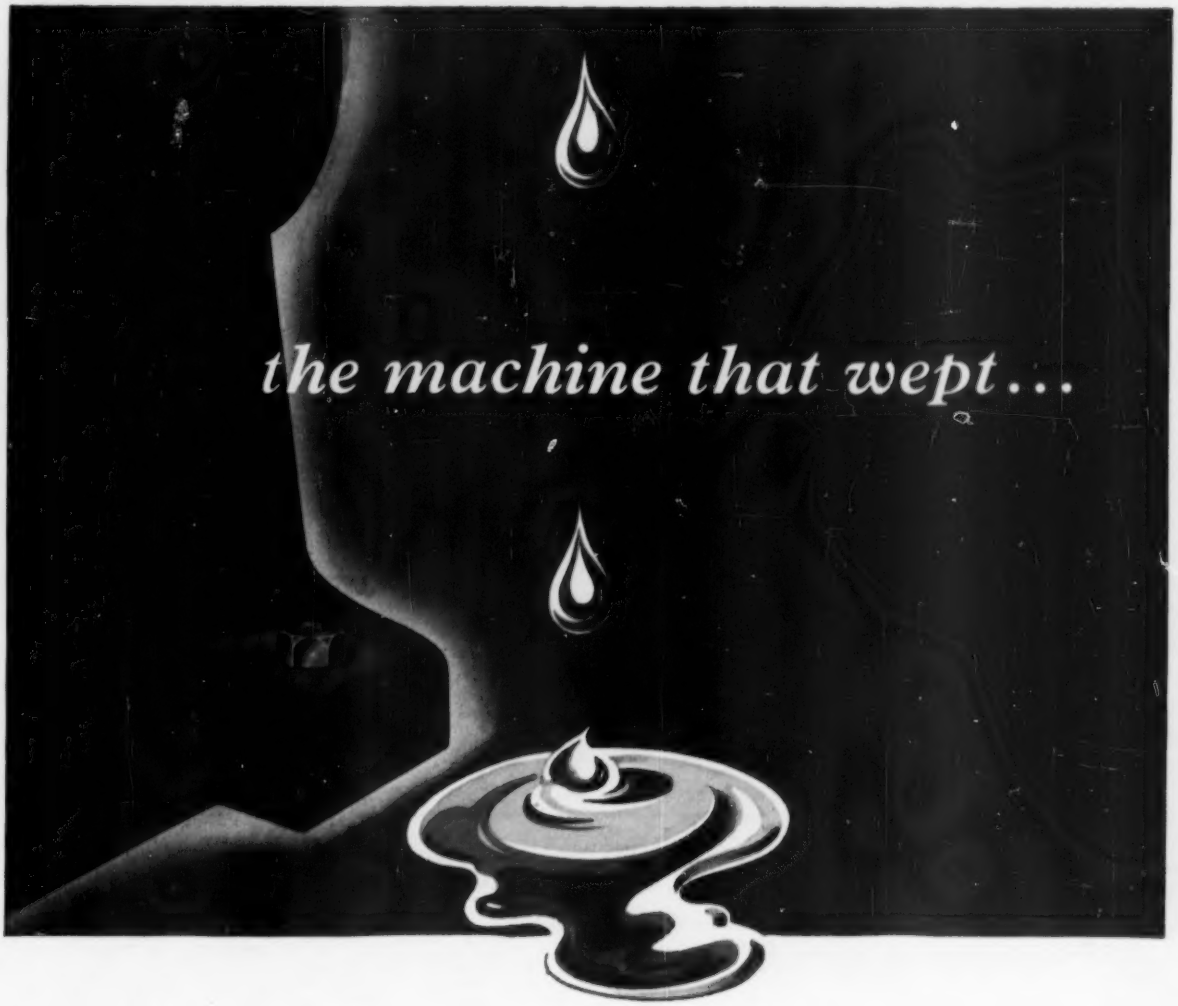

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Printed in Great Britain for the Publishers, ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1, by James Cond Ltd., Charlotte Street, Birmingham 3. "Automobile Engineer" can be obtained abroad from the following: AUSTRALIA & NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service Ltd.; Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd.; Wm. Dawson & Sons (S.A.) Ltd. UNITED STATES: The International News Co. Entered as Second Class Matter at the New York, U.S.A., Post Offices.

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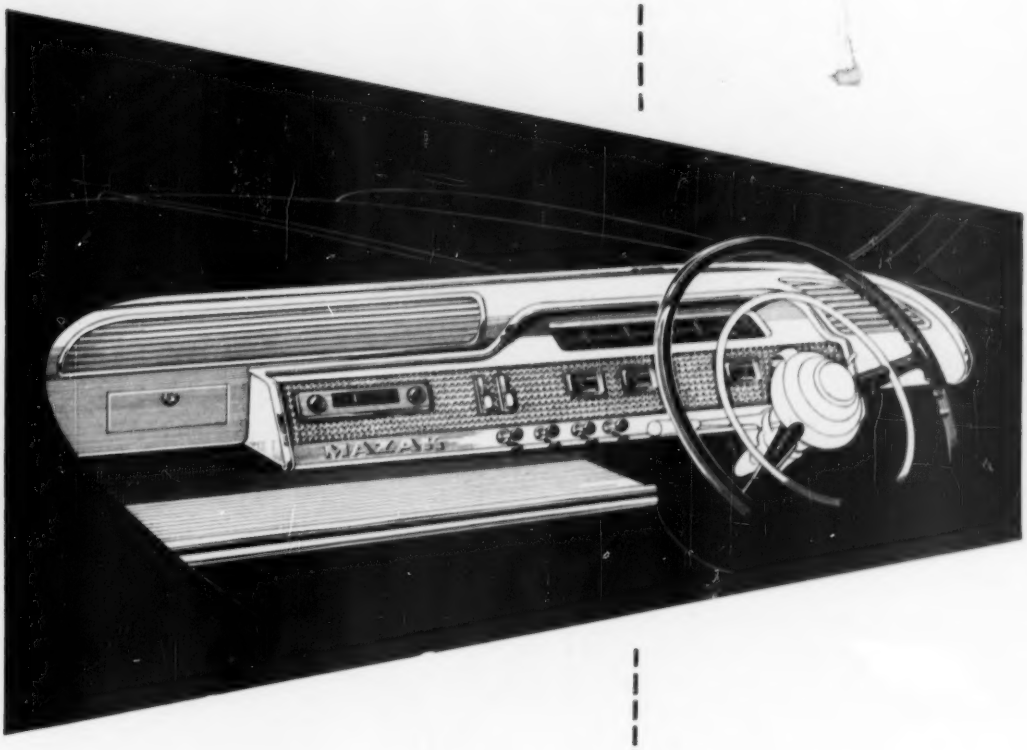

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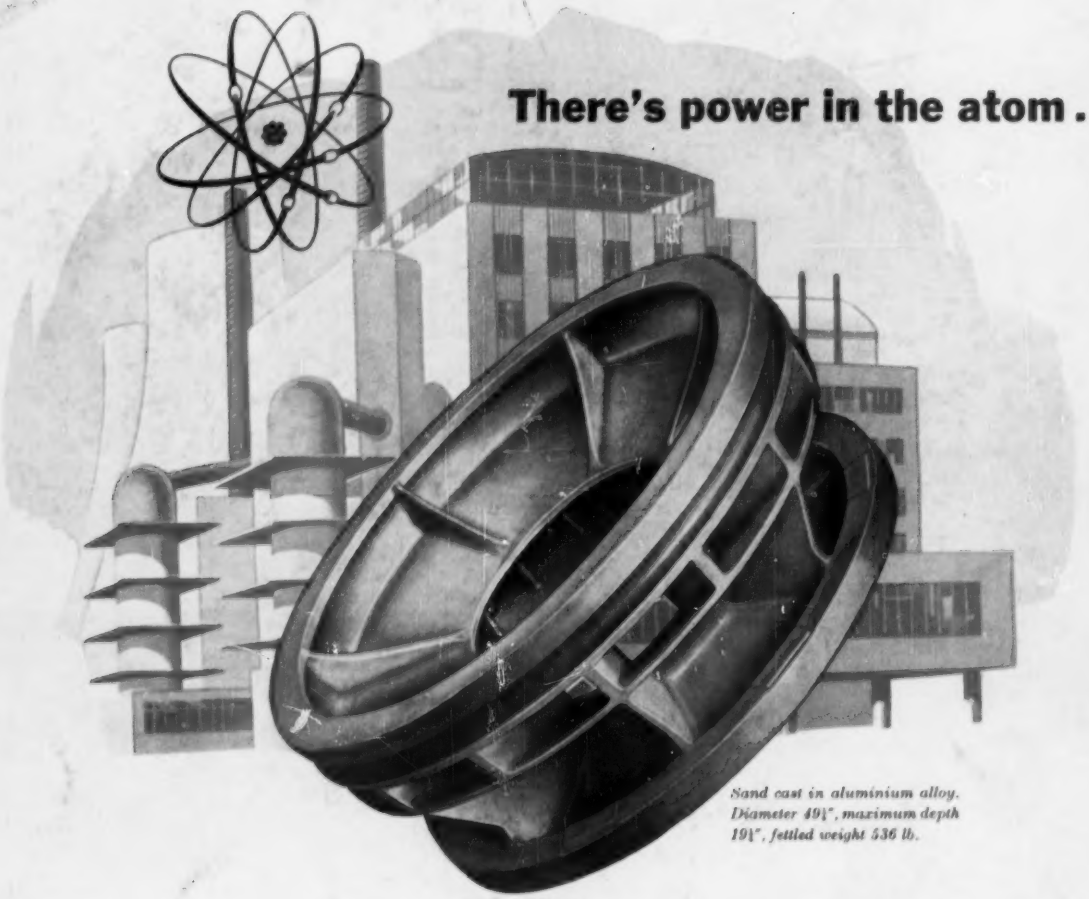

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